Impact of Stocked Rainbow Trout on Resident Salmonid Populations

Phase 1, Scoping Study

Institute of Freshwater Ecology

R&D Technical Report W61

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Phase 1, Scoping Study

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Statement of use
This report includes a full literature review on the impact of Rainbow Trout on salmonid species. The report will provide information to fishery scientists. The results will feed into a further phase of research.

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EXECUTIVE SUMMARY

A full literature review of the impact of rainbow trout on native salmonid species has been carried out. It revealed that extensive introductions of the species have taken place throughout the world and that in some areas self-sustaining populations have been generated which have had severe impacts on native salmonids. In Britain, although there are a number of instances of wild breeding only two examples of self- sustaining populations have been recorded.

Existing Agency data, including Section 30 records, relating to the impact of introduced rainbow trout on resident salmonid populations were reviewed. There was little direct evidence of impact chiefly because surveys were of a general nature and were not specifically directed at the study of rainbow trout. Rainbow trout have been found to eat juvenile salmonids and the fry of other species.

Many Agency Regions have no firm policy while others have strict written regulations relating to the introductions of rainbow trout. Even between Areas of the same Region there are different policies. All Regions allow introductions to still waters (with a few notable exceptions) but for running waters the policies range from complete acceptance of introductions to a complete ban, many are now actively discouraging the introduction of rainbows without a formal ban. Most introduced fish are of takable size and the vast majority are introduced to still waters. The majority of introductions in many Agency Regions are before the start of the trout fishing season and may coincide with the emergence of juvenile salmonids from spawning areas.

Little or no historical information on introductions of rainbow trout was forthcoming from the Agency regions. Such information must exist in some angling club records but this would be difficult to obtain and collate.

Maps were produced of the distribution of breeding and self-sustaining populations of rainbow trout in rivers of England and Wales.

Risks of stocking with rainbow trout are mainly evident from foreign information. Disease problems seem to be negligible. In the event of self-sustaining populations arising, there is no doubt that the impact on indigenous salmonid stocks can be severe although this is not yet evident in this country except for an indication that there may be an inverse relationship between year-class success of brown and rainbow trout in the two self-sustaining populations which are known to exist.

Rainbow trout have been known to escape in very large numbers, usually from fish farms, into rivers but in the majority of cases these fish had disappeared from the systems within a year.

A series of experiments was designed to investigate the significance of territorial conflicts between rainbow trout and native salmonids, to study the spawning interactions with other salmonids, to investigate the importance of piscivory and to assess the capacity of introduced fish to become self-sustaining.

In conclusion, it is recognised that there is a strong socio-economic pressure to allow introductions of rainbow trout as they are cheap and easier to catch than brown trout. It is further recognised that it would be almost impossible to ban introductions from all waters. There is a debate over

whether it is better to introduce brown trout or rainbow trout. Brown trout can be genetically polluting and rainbow trout have the potential to cause a substantial impact on native salmonids chiefly by interaction at the juvenile stage of self-sustaining populations. By introducing all female or sterile strains of rainbow trout, the possibility of this can be minimised.

A general policy should be to stock with all female or sterile rainbow stock where the pressures to introduce are overwhelming. Care should be taken to limit or ban introductions where pure wild stocks of salmonids occur, in watercourse where recolonisation of salmon is being encouraged, and in catchments where natural populations are in decline and the number of smolts need to be maximised.

This work feeds into the Agency's overall contribution to the Biodiversity Action Plan for chalk streams.

1. INTRODUCTION

1.1 The rainbow trout

The rainbow trout is a polymorphous salmonid fish whose native distribution is restricted to the drainage systems on the western coast of North America, extending from Alaska in the north to Mexico in the south (MacCrimmon, 1971). At the beginning of the century the migratory form (steelhead) was considered to be a different species to the non-migratory form (rainbow). Within each of these two 'species', four and six sub-species were recognised. Subsequently most of these forms were discarded by ichthyologists and Regan (1914) considered all these forms to be the same species. However, a number of terms to describe the differing behaviours apparent in the species survived from these original distinctions. Worthington (1941) made a distinction between the migratory steelhead (*gairdnerii*), the spring spawning non-migratory form (*irideus*) and the autumn spawning non-migratory form (*shasta*). There was some controversy over the origins of the '*shasta*' form; it was thought to come from the lower reaches of the McCloud river which rises in Mount Shasta (Walker & Patterson, 1898). However, it was concluded by Worthington (1941) that this form was the result of selective breeding and that there are no known natural forms of autumn spawners in the rainbow trout's native range.

1.2 Background

Each Agency Region appears to have a different policy in respect of the circumstances and criteria applied to allowing the stocking of rainbow trout. In some cases, large numbers of rainbow trout are freely stocked into rivers, streams and lakes already carrying established populations of brown trout, salmon or even char. The impact or potential impact of the stocked fish has tended to be unquantified or unknown.

Fisheries Officers and Managers in the Agency felt strongly that it was difficult to progress the development of consenting policy without an objective basis to do so. The issue of rainbow trout stocking is very political because of perceptions and prejudices and has generated considerable debate at respective Regional Fisheries Advisory Committees (RFACs).

In certain situations such as southern chalk streams, it is widely felt that the stocking of large numbers of rainbow trout could have a significant impact on native fish stocks through predation. Other factors such as interspecific competition and the importation of disease must also be considered.

1.3 Overall Project Objectives

Phase 1 of the project is to review the existing data, literature and other information on stocked rainbow trout and their impact on resident salmonids, in order to produce experimental designs which will provide the answers required to produce a nationally consistent and acceptable policy on rainbow trout stocking.

1.3.1 Specific objectives

To produce a full literature review of the impact of rainbow trout on native salmonid species to include ecology and consider other factors which may limit populations.

To review existing Agency data on the impact of rainbow trout on resident salmonid populations.

To review existing Agency policy including current practices (ie what is stocked, where and why) and historical introductions.

To produce a map showing where rainbow trout populations are now known to be self-sustaining.

To define the potential or proven risks from stocking rainbow trout.

To assess the significance of other ways in which rainbow trout have escaped into the wild eg accidental release or loss from fish farms.

To produce, in the form of an R&D Note, costed experimental designs and potential site locations which would answer specific questions on impacts raised from the literature and data review.

2. LITERATURE REVIEW

2.1 Introduction

Literature searches of Aquatic Science and Fisheries Abstract database for the period 1979-present and of the FBA/IFE current awareness databases were made. This raised >500 references concerned with rainbow trout. Titles and abstracts of these have been read and from these a database containing 190 records was compiled. Inter-library loans were obtained for the references not held by the Freshwater Biological Association's library at the Ferry House. Examination of the references showed that some items were irrelevant, but identified further references of relevance. These latter references were also obtained and included in the Bibliography, which contains a total of 168 items.

This literature review concerns the impact of rainbow trout *Oncorhynchus mykiss* on native salmonid species, dealing with the history of the introduction of this species, the incidence of the establishment of self-sustaining populations and potential impacts under the headings of competition, predation, disease and hybridisation.

2.2 History of rainbow trout introductions

2.2.1 Worldwide introductions

MacCrimmon (1971) gives a detailed account of the history of worldwide rainbow trout introductions. They have been introduced into every continent with the exception of Antarctica, and have established self-sustaining populations throughout parts of North America, South America, Europe, Africa, Asia and Australasia. This latest assessment of worldwide distribution describes a range from the Arctic circle to the equator in the northern hemisphere, and from the equator to 55°S in the southern hemisphere.

MacCrimmon (1971) analyzed the world distribution and concluded that survival was limited primarily by water temperature and precipitation. Where rainbow trout made a significant contribution to local fisheries it was suggested that temperature reached between 15 and 20°C for prolonged periods each year. Water temperatures below 13°C during spawning were felt to be critical in determining the establishment of self-sustaining populations, and areas where precipitation were lower than 25 cm per year appeared not to support self-sustaining populations. This general assessment appears to be confirmed by the success of trout introductions to Australia (Tilzey, 1977).

2.2.2 Introduction to the United Kingdom

An account of the introduction of rainbow trout to the United Kingdom and Europe is given in both Walker & Patterson (1898) and Worthington (1941) and the following is taken from these accounts.

The first shipments to England were as eggs to the National Fish Culture Association at Delafield in 1884 and 1885. On hatching, a number of these fish were distributed to other fish culturists in England. Other shipments were sent to Sir James Maitland at Howietoun in Scotland where breeding rainbows were established in 1887 (Walker & Patterson, 1898). Shipments from America continued every winter to a number of hatcheries in the United Kingdom between the years 1888 and 1905. During the same period shipments were made to other parts of continental Europe, most notably Germany, and during the latter years of the 19th century large numbers of rainbow eggs entered England from continental hatcheries. These original stocks are thought to have comprised a mixture of steelhead, '*shasta*' and '*irideus*', as well as hybrids of these types (Worthington, 1941).

Between 1905 and 1931, there are no records of further shipments of eggs from America. However, by 1931 many British trout farmers had become unhappy with the condition of British stocks, presumably because they predominantly matured in the spring and had migratory tendencies. Efforts were made to obtain pure '*shasta*' stock from America, and shipments of these were made in the winters of 1931-32 and 1938-39. These fish matured in the autumn and had less of a tendency to migrate to sea. The progeny of these were distributed widely throughout Britain and it was thought by Worthington (1941) that they would form the bulk of future production in the UK. This was confirmed by Frost (1974) who stated from limited data that about twice as many hatcheries bred only '*shasta*' as bred '*shasta*' and '*irideus*'.

2.2.3 Introductions to British inland waters

The two previous extensive surveys of stocking of rainbow trout into British inland waters, Worthington (1941) and Frost (1974), have shown a rapid growth in the number of waters containing rainbow trout this century.

In 1941, Worthington names approximately 50 inland water bodies in the British Isles that had received stockings of rainbow trout prior to 1940, of which two were in Ireland. In addition he states that a few private lakes were stocked as were some unnamed tarns in the Lake District. He gave no information on any introductions in Scotland.

By 1971, Frost (1974) gives a figure of 494 for the number of waters in Great Britain and Ireland containing living rainbow trout, of which 29 were in Ireland. A number of waters did not form part of that survey and these are in addition to 67 instances where rainbow trout were known to have been present prior to 1971, but the status of which was not known in 1971. Data from Frost's survey indicated that introductions were few between 1940 and 1950, but accelerated after 1950 and were still accelerating in 1971. Bucknall (1968) recorded the growing use of rainbow trout to restock chalk streams and combat the increased fishing pressures in these rivers. Rainbows were reared in stew ponds on the River Test at this time.

Running waters made up 60% of the water bodies stocked in 1940 (Worthington, 1941) but by 1971 this figure had fallen to 20% with 80% being stillwaters (Frost, 1974).

Today the use of water supply reservoirs as fisheries is common and rainbow trout have been stocked in these frequently because there is a close relationship between the numbers of rainbow trout stocked to those caught, whereas this is not always the case with brown trout *Salmo trutta* (Fleming-Jones, 1974; Fleming-Jones & Stent, 1975) and recapture rates are often better for rainbow trout (Pawson, 1991).

2.3 Numbers of self-sustaining populations

Despite the massive increase in the number of waters stocked with rainbow trout there are surprisingly few instances where self-sustaining populations have been recorded. Worthington (1941) lists 14 localities where rainbow trout had been known to breed. He suggests that in the majority of cases these are not self-sustaining populations but are supported by frequent stocking. The possible exceptions to this were the Derbyshire Wye (Tew, 1930; McCaskie, 1939), Blagdon Reservoir, River Chess, River Misbourne and Lough Shure in Ireland.

In 1971, there were reputed to be the same number of water bodies supporting self-sustaining populations as there were in 1940 (Frost, 1974), although a number of the locations had changed with some of the previously noted populations dying out. The five recorded in 1971 were the Derbyshire Wye, the River Lathkill a tributary of the Derbyshire Wye, a tributary of the Leigh Brook, Lough Shure in Ireland and Lough na Liebe in Ireland. In addition to these, another 34 showed evidence of spawning activity, 16 of which resulted in the presence of juvenile rainbow trout. For the remaining 18 there was only evidence of spawning activity. Between 1940 and 1971 the River Chess was thought to have lost its population to increased sewage pollution and both Blagdon Reservoir and the River Misbourne had been put into a category where there is evidence of reproduction, but not of self-sustaining populations.

Since this last census in 1971, there have been some concerns voiced that rainbow trout are adapting to British waters and beginning to breed in more places (e.g. Pearson, 1977; Phillips, Beveridge & Ross, 1985). There are published records of rainbow trout spawning in a small loch in Inverness-shire (Lever, 1977), in Loch Fad, Isle of Bute (Phillips *et al.*, 1984) and in a tributary of Llyn Brenig, North Wales (Brown & Diamond, 1984). Many of the large water supply reservoirs, where stocking of rainbow trout is intense, have spawning populations in the tributaries running into them, although it is difficult to determine whether these are populations capable of sustaining themselves in the absence of stocking. A similar phenomenon occurs in Finger Lakes, USA (Hartman, 1959), although here there is more evidence of potential self-sustaining populations with definite records of fish spawning in the tributaries which are the progeny of previously naturally spawned fish. This ability to become established and be more successful at outcompeting brown trout, on the east coast of North America and Canada, seemed to coincide with a shift to earlier spawning in rainbow trout (Dodge, 1983). This trend may be occurring in the United Kingdom with both rainbow and brown trout spawning in November in North Wales (Brown & Diamond, 1984).

2.3.1 Reasons for the lack of self-sustaining populations in the UK

At first sight there would appear to be little reason for rainbow trout failing to establish self-sustaining populations in many of the waters of the United Kingdom. Walker & Patterson (1898) discuss the likely success of rainbows and say that they will always fail if placed in cold waters i.e. where the waters are liable to freeze or fall below 35°F (1.7°C), that they do well in warm waters where the temperature is little changed. The species can withstand temperatures as high as 85°F (29°C). MacCrimmon (1971) suggested that water temperatures below 13°C during spawning and precipitation above 25 cm per year were felt to be critical requirements in determining the establishment of self-sustaining populations. Generally, rainbow trout are thought to be more tolerant of eutrophic conditions than brown trout (Frost & Brown, 1967; Taylor, 1978; Phillips, 1984). Jowett (1990) studied brown and rainbow trout populations at 157 riverine sites in New Zealand in an attempt to identify the factors that determined the distribution of each species. Factors which had an influence were geology, temperature, hydrology and the amount of cover. Many of these factors are interlinked but Jowett (1990) concluded that rainbow trout did best in spring fed rivers with stable flow and temperature regimes. Clearly, on the basis of the above descriptions, many of the United Kingdom waters have habitat suitable for rainbow trout survival and reproduction.

The use of all female, sterile or triploid stock in farms is one potential reason for the failure of stocked fish to produce breeding populations (Philippart, 1989). Phillips (1984) cites a low probability of reaching sexual maturity and finding a suitable spawning area with a suitable mature partner. Many of the original rainbow trout stocks may have come from a small number of parents and combined with inbreeding on farms this would have reduced genetic variation (Ferguson, Ihssen & Hynes, 1991) and therefore lowered the survival chances of the progeny of those that were capable of maturing. Rainbow trout may be the least resistant of the salmonids to acid waters (Grande, Muniz & Andersen, 1978), and embryos have been shown not to survive below a pH of 4.49 (Kwain, 1975), although Frost (1940) describes a population breeding in a peat Lough on Arranmore where the pH was 4.8. Most authors have attributed the lack of success in establishing populations to competition with the earlier hatching brown trout (Walker & Patterson, 1898; Jenkins, 1969b; Phillips *et al.*, 1984), with successful breeding occurring only where brown trout are absent or in low numbers (Frost, 1974; Lever, 1977).

Bielby (1971) describes an attempt to establish rainbow trout in two small streams in Cornwall. To aid their introduction and establishment, native salmonids were greatly depleted by electric fishing. The venture was described as a failure with most of the rainbow trout disappearing over the period of a year, survival being between 1.2% and 2.1%. There may have been a large number of reasons for this. Firstly the fish were only stocked during one year and the hatchery fish used may have been poor quality and poorly adapted to the natural environment. Such survival rates may have been expected for hatchery reared fry, no matter what species they were. Further some of the fish used were from autumn spawning stock which is probably the result of selective breeding and not one found naturally. Some of the males were mature within their first year and this may not have helped their survival. The numbers of natural salmonids also increased over the period of the experiment. This experiment was probably not good evidence that rainbow trout populations would not establish themselves if given enough impetus.

Rainbow trout have established populations in sympatry with brown trout in New Zealand (Tilzey, 1971; 1972; Hayes, 1987; 1988 a & b). In some cases the rainbow trout appear to be the dominant species whereas in others the brown trout are dominant. In one population where rainbow trout are dominant this appears to be affected by the rainbow trout overcutting the brown trout redds, where spawning grounds are limiting. In this case there is very high mortality of brown trout eggs and they are not very numerous (Hayes, 1988 a & b). In another system, brown trout juveniles were in greater abundance and competition from these resulted in greater dispersal of rainbow trout fry, which were then predated on heavily by brown trout adults at a lake inlet further downstream (Tilzey, 1971; 1972)

In Tasmania, brown trout have become dominant in most waters where the two species co-exist (Cadwallader, 1983), although long-term records of the population in the Great Lake of that country indicate that there have been periods when either one of the species has dominated over the other during this century, and this may have been due to the availability and use by rainbow trout of inshore spawning grounds during periods of high inundation.

Thus, the issue of establishing rainbow trout populations would seem to be complicated and, in part, dependent on the interactions of habitat availability and life history strategy, particularly when evidence from introductions to other countries is considered as well as evidence from this country.

2.4 Behaviour and performance of stocked fish

Needham & Slater (1944) and Shetter (1947) found that stocked rainbow trout had greater survival in rivers when introduced in the absence of wild trout.

Helfrich & Kendall (1982) found that 59% of stocked catchable sized rainbow trout were recaptured by anglers downstream of the point of stocking. Median dispersal distance was 60 m. Trout stocked into pools generally moved less than those stocked into riffles. In a number of similar studies, downstream movements have been noticed for rainbow trout following stocking (Trembly, 1943; Cooper, 1952; Newell, 1957; Ratledge & Cornell, 1953; Moring & Buchanan, 1978; Cresswell, 1981)

Hatchery bred steelhead had a lower survival than wild steelhead in natural channels (Reisenbichler & McIntyre (1977), and the degree of inbreeding had a significant impact on the survival of rainbow trout (Kincaid, 1976). The reproductive success of hatchery reared rainbow trout was less than that for wild run fish (Chilcote, Leider & Loch, 1986) and their contribution to future generations was much lower than that of wild stocks (Leider *et al.*, 1990).

2.5 Impacts of stocked rainbow trout on resident salmonid populations

2.5.1 Introduction

The use of hatchery reared trout to supplement natural populations has been an accepted fishery management practice for many years. However, the impacts of stocking on both the stocked fish and wild fish is studied infrequently when compared to the number of stocking events. In England and Wales there are three resident salmonid species. These are the brown trout *Salmo trutta*, salmon *Salmo salar* and Arctic charr *Salvelinus alpinus*.

The impacts of rainbow trout introductions on native brown trout and Atlantic salmon have been the subject of study by fishery ecologists for some time (Worthington, 1941; Frost, 1974; Gibson, 1981; Johnson, 1981; Whoriskey, Naiman & Heinermann, 1981). Concerns cover a wide variety of issues including competition, predation, hybridization, and introduced diseases.

Most of the literature relevant to impacts concerns itself with competition during the early life stages in stream resident fish. This is felt to reflect a generally held belief that this is where introduction of exotic fish is likely to impact most where salmonid fish are concerned. Therefore this review considers a general discussion on competition, before considering impacts on a species by species basis covering all life stages and habitats.

2.5.2 Competition

Competition amongst salmonid juveniles in streams takes place on the dimension of space rather than for food (Chapman, 1966). Individuals compete for positions which are valued in terms of the amount of food that can be acquired at them (Fausch & White, 1981; Bachman, 1984). These positions are typically in areas of low flow but close to areas of high flow from which drifting food items can easily be intercepted (Wankowski & Thorpe, 1979; Fausch, 1984). Position choice is related to net energy gain (Hill & Grossman, 1993). Often individuals utilise different positions for feeding, resting and cover (Jenkins, 1969b; Fausch & White, 1981).

Competition for territorial positions is determined by agonistic behaviour and displays, and is a form of interference competition. Dominance is predominately determined by size and species (Chapman, 1962; Gibson, 1981), although prior residence can have a minor influence (Noakes, 1978; Hayes, 1989) and can influence growth rates and life-history strategy (Thorpe, Metcalfe & Huntingford, 1992), as well as result in the displacement of subordinates (Hearn, 1987).

Salmonids which have evolved sympatrically have developed mechanisms to allow co-existence usually by partitioning the available habitat (Allee, 1981). When two closely related species of salmonids co-exist they often interactively segregate (Nilsson, 1966) and this reduces the impacts of competition. Overall production increases when populations of equal density of salmonids consist of more than one species. Mork (1982) confirmed this by rearing brown trout and rainbow trout both together and separately and found that specific growth rate was better when the species were reared together.

The importance of space to stream dwelling salmonids is confirmed by the frequently found similarity in the diets and feeding behaviour of coexisting species (Jenkins, 1969a; Elliott, 1973; Wagner, 1975; Johnson, 1981; McLennan & MacMillan, 1984; Glover & Sagar, 1991), although some authors (Idyll, 1942; Tebo & Hassler, 1963) claim to have found subtle differences between the diets of brown trout and rainbow trout. Williams (1981) suggests that the diet of stream dwelling salmonids is determined largely by availability.

2.5.3 Impacts of rainbow trout on Arctic Charr

Arctic charr are only present in a few lakes in this country. There are no known records of any impacts of stocked rainbow trout on this species of charr, although rainbow trout are known to be present in some Scottish lochs containing Arctic charr. Charr are capable of completing their life-cycle within lakes (Mills & Hurley, 1990) and no impacts of the presence of rainbow trout on charr were detected in Loch Awe (Duncan, 1991). However, in parts of America, the rainbow trout has been introduced to a number of rivers which contain brook trout *Salvelinus fontinalis*, a closely related species.

Rainbow trout have been blamed for the decline of brook trout since the 1930's in the Great Smokey mountains USA (Larson & Moore, 1985; Moore & Larson, 1980; Moore, Ridley & Larson, 1980, 1981; Moore, Larson & Ridley, 1984, 1986). Brook trout showed a decline in growth after the emergence from eggs of rainbow trout in a tributary of Lake Superior (Rose, 1986). It was hypothesised that this resulted in a higher mortality of brook trout during their first winter and was a means by which rainbow trout excluded brook trout. Whitworth & Strange (1983) found rainbow trout grew faster than brook trout living sympatrically and thus maintained a size advantage. This may have been important in competitive interactions. Helfrich, Wolfe &

Bromley (1982) found rainbow trout to be more mobile and aggressive and able to intercept more prey items than brook trout. Six years of electric fishing for rainbows in the Great Smokey mountains reduced this population greatly and resulted in an increase in the population of brook trout (Moore *et al.*, 1986).

However, where the two species were stocked into some previously fishless lakes, brook trout displaced rainbow trout from lakes with small outlets but not from lakes with large outlets. This phenomenon is probably the influence of lake outlet size on the availability of spawning grounds (Donald, 1987).

Any planned introductions of rainbow trout to lakes containing Arctic charr should be considered carefully, particularly where charr use rivers for spawning and rearing of juveniles.

2.5.4 Impacts of rainbow trout on Atlantic salmon

Concern has been expressed, particularly on the east coast of North America, of the impacts of introduced rainbow trout populations on the native Atlantic salmon (Chadwick & Bruce, 1981; Whoriskey *et al.*, 1981). This problem is probably more acute in America than in the British Isles because there seems to have been greater success of rainbow trout establishing self-sustaining populations in that country.

The habitat requirements of the two species show a number of similarities. Requirements for spawning gravels are virtually identical for stream spawning salmonids. These are clean, non compacted, stable, permeable gravels with particle sizes of a median diameter of 20-30 mm, often in the tails of pools, with a water velocity of greater than 15 cm s^{-1} and a depth usually greater than 15 cm (Greeley, 1932; Needham & Taft, 1934; Orcutt, Pulliam & Arp, 1968; Hartman & Galbraith, 1970; Peterson, 1978; Crisp & Carling, 1989). In common with Atlantic salmon, rainbow trout are known to home to spawning grounds (Lindsey, Northcote & Hartman, 1959).

Where Atlantic salmon and rainbow trout differ is over the timing of spawning. In this country salmon spawn between December and early February. There are few populations of spawning rainbow trout in this country, but in their native range and in other areas where they have been introduced and established self-sustaining populations they spawn later than the native salmonids in this country. In British Columbia, rainbow trout spawn from March to May (Smith, 1969), May in Idaho (Reingold, 1965). In Lake Erie there were both autumn and spring runs of rainbow trout entering the streams but spawning only appeared to take place in the spring (Wenger, Lichorat & Winter, 1985). One Great Lakes population of rainbow trout spawned over an extended period from late December to the end of April (Dodge & MacCrimmon, 1970), although the majority spawned during late March and April (Biette *et al.*, 1981; Dodge & MacCrimmon, 1971). Where there are both wild and hatchery reared rainbows and steelhead, a spawning season may extend over a period of six months or more (Leider, Chilcote & Loch 1984) and in some places where they have been introduced have been shown to spawn at any time between November and July (Agersborg, 1934).

This later and somewhat extended spawning season exhibited by rainbow trout has led to some concerns that spawning rainbow might overcut and disturb salmon redds causing high mortality to both eggs and alevins (Gibson, 1981), although there is no published literature recording examples of Atlantic salmon redd disturbance by rainbow trout. It is also possible that this problem is compounded because the digging of redds improves the quality of gravel for subsequent spawners, by cleaning the gravel of fine particles, and McNeil (1967) demonstrated contagious distribution of pink salmon spawning redds in an experimental channel.

In the juvenile stages, Atlantic salmon, when small, tend to prefer riffles during the summer at quoted velocities between 50-65 cm s^{-1}, at depths between 10 and 15 cm over a substratum of pebbles. Larger parr prefer greater depths over a substratum of boulders (Lindroth, 1955; Gibson, 1966; 1978; Symons & Heland, 1978; Solomon, 1983; Kennedy, 1984; Hearn & Kynard, 1986; Kennedy & Strange, 1986; Bley, 1987; Heggenes & Borgstrom, 1991). Rainbow trout juveniles tend to prefer slower velocities and have been shown to occupy pools more often than salmon. Quoted preferred velocities are at 30 cm s^{-1}, at depths between 30 and 120 cm over gravel and cobble substrata (Hartman, 1965; Bustard & Narver, 1975; Hearn & Kynard, 1986; Moyle, Baltz & Knight, 1983). During the winter months, both species seek cover in stream bed interstices (Bustard & Narver, 1975; Rimmer, Paim & Saunders, 1983, 1984), although when coexisting, rainbow trout used cover found in pools whereas salmon used cover in riffles (Hearn & Kynard, 1986)

Hearn & Kynard (1986) studied the habitat utilisation of Atlantic salmon and rainbow trout juveniles in an experimental channel. The study was during the summer and covered both the 0+ and 1+ age groups. The 0+ salmon were larger than the rainbow trout born in the same year but by the next year they were of equal size. In the experimental channels, both 0+ and 1+ rainbow trout preferred the deeper areas during intraspecific studies, whereas the Atlantic salmon occurred equally in pool, riffle and intermediate areas. During interspecific trials the 1+ salmon used the riffle habitat more often, suggesting they may have been excluded from the pool and intermediate areas by the rainbow trout. No similar niche shift was noticed for 0+ salmon, suggesting that there was no impact on these when coexisting with rainbow trout. However, Gibson (1981) found that the greater aggression in steelhead juveniles could displace salmon parr from their preferred positions in the riffles, even though they were slightly larger than the steelheads. There is thus some difference between the outcome of these behavioural experiments and further work may be required. Both authors noted the tendency of rainbow trout to be distributed throughout the water column whereas salmon were often close to the substrate.

Jones & Stanfield (1993) conducted a field experiment in eight study sites to assess the impact of the presence of other salmonid species including rainbow trout on the growth and survival of hatchery reared salmon fry. Four sites were manipulated and had other salmonids removed and four sites were left with salmonids present. Large habitat differences and lack of success at removing competitors confounded the results but the growth rate and survival of salmon was greater in the manipulated sites. However, this was not a good test of competition because the total biomass of fish was lower in the manipulated sites and therefore it was not possible to separate intraspecific from interspecific competition.

2.5.5 Impacts of rainbow trout on brown trout

Rivers

Rainbow trout and brown trout have similar life history strategies, that is, migratory as well as non-migratory forms (Hartman, 1959; Withler, 1966) and there have been concerns over the potential impacts of the introduction of exotic rainbow trout on native brown trout populations (Worthington, 1941; Kocik & Taylor, 1991).

As with Atlantic salmon, brown trout spawn earlier than rainbow trout and both species share habitat requirements for spawning. Thus there is a similar threat of over cutting of brown trout redds by rainbow trout and instances of this are recorded in other countries where the two species are now coexisting.

Spawning of Great Lake rainbows takes place when brown trout alevins are still in the gravel and redd disturbance at this stage may cause high mortality of these, limiting brown trout production (Kocik & Taylor, 1994). This later spawning was evident in New Zealand and in one stream where there was strong competition for spawning grounds, spawning success was greatest in the group of late spawning rainbows, which overcut the redds of previous spawners including the brown trout and caused such high mortality (0.2% survival) that the brown trout population was numerically subordinate to the rainbow trout (Hayes, 1988a & b).

The thermal tolerance for rainbow trout and brown trout appear to be very similar at approximately 29°C for both (Lee & Rinne, 1980). No statistical differences were found between brown trout and rainbow trout for critical thermal maxima (Grande & Andersen, 1991). There are reported differences in the temperature requirements for egg hatching in the two species. Humpesch (1985) reports brown trout eggs hatching at a minimum temperature of 1°C, in comparison to 3°C for rainbow trout eggs. Optimum temperatures were 5°C for brown trout and 8°C for rainbow trout. Maximum temperatures were 16°C for brown trout and 20°C for rainbow trout.

Juvenile brown trout have recorded preferences for flow velocities less than 25 cm s^{-1} in shallow water during their first year, moving to deeper (> 30 cm) and faster (> 30 cm s^{-1}) water, as they grow larger. They are particularly cover orientated and tend to select feeding positions close to suitable cover (Bohlin, 1977; Egglishaw & Shackley, 1982; Heggenes & Traaen, 1988a & b). Rainbow trout juveniles tend to prefer similar velocities although at comparatively greater depths and do not have the same rigorous requirements for cover (Hartman, 1965; Butler & Hawthorne, 1968; Bustard & Narver, 1975; Hearn & Kynard, 1986; Moyle *et al.*, 1983). Hayes (1988b) found differences in the emergence behaviour of rainbow trout and brown trout. Rainbow trout were active in the water column and at the surface at night and were therefore more pre-disposed to downstream dispersal than brown trout which hugged the substrate.

As previously stated, competition with brown trout is one of the most frequently quoted reasons for the apparent lack of success in rainbow trout establishing self-sustaining populations in this country. In the Great Lakes region, the brown trout emerge 5-9 weeks earlier from the redds than do rainbow trout (Seelbach, 1993) and this gives the brown trout a competitive size advantage in its early stages (Kocik & Taylor, 1994), resulting in greater downstream dispersal of rainbow trout (Tilzey, 1971; 1972), although some authors consider that this size difference may reduce potential competition between these species through size related habitat requirements (Hayes, 1988b).

However, studies which have examined competition between the juveniles of these two species have found evidence of spatial segregation. Kocik & Taylor (1991) found that steelhead fry made no difference to the growth rates and survival of brown trout fry when introduced to natural stream channels. Kocik & Taylor (1994) hypothesised that vertical stratification of habitat use between the species was important at partitioning them, with brown trout hugging the substrate whilst rainbow trout lived in mid water. Under equal salmonid densities with and without rainbow trout fry, they found that mortality and growth of 0+ brown trout were not affected in sympatry as much as they were in allopatry. Hayes (1987) found that size differences of 1.7 times were enough to reduce aggression between the species and spatial segregation of early and late hatching individuals may reduce competition.

Behaviourally, both species exhibit similar agonistic patterns, although there were minor differences in that rainbow trout used nipping and chasing, whilst brown trout used threat displays (Hayes, 1987). Rainbow trout fry were found to be more dominant than brown trout fry (< 35 mm), in velocities greater than 10 cm s^{-1}, which is at the higher end of the preferred velocities for fry of this size. This was attributed to the greater suitability of the agonistic nipping and chasing of rainbow trout to high flows than threat displays, which led to displacement of brown trout fry. At larger sizes, brown trout became more dominant at velocities below 15 cm s^{-1}, which is at the lower end of the preferred velocities of fish of this size (Hayes, 1987). To fully understand the interactions of size and habitat, such experiments need to be repeated over a wide suite of velocities, depths and temperatures.

Kocik & Taylor (1994) found that rainbow trout had a faster growth rate than brown trout, such that by the end of the first year, size differences resulting from the later spawning of rainbow trout had disappeared.

Adult brown trout generally prefer velocities greater than 30 cm s^{-1} and depths greater than 30 cm. They have a requirement to be close to suitable cover (Belaud *et al.*, 1989; Lambert & Hanson, 1989). Rainbow trout adults have been quoted as requiring similar flows to brown trout and depths between 60 cm and 600 cm, although they have much less affinity for cover than brown trout (Butler & Hawthorne, 1968; Lewis, 1969; Gosse, 1982).

Some authors take the view that stocked rainbow trout will have little impact on brown trout adults, as these will dominate over rainbows because they generally grow larger (e.g. Gatz, Sale & Loar, 1987), depending, of course, on the size of fish stocked. McLennan & MacMillan (1984) reported that where brown trout were rare or infrequent, rainbow trout utilised shallower feeding stations than when brown trout were more frequent. They suggested this was because brown trout excluded rainbow trout from preferable areas. This was attributed to the larger size of the brown trout. Gatz *et al.*, (1987) present evidence of rainbow trout occupying positions away from the preferred habitat of brown trout, for both 0+ and older fish. They suggested this was as a result of interference competition, with the behaviourally dominant brown trout inducing habitat shifts in rainbow trout. Shirvell & Dungey (1983) found that brown trout inhabited the same microhabitats in the presence or absence of rainbow trout, inferring that rainbow trout had little impact on adult brown trout.

Conversely, studies at the population level have shown quite dramatic impacts on brown trout in the presence of rainbow trout. Kruger, Taylor & Ryckman, (1985) found that the angler harvest of brown trout had decreased during a period when steelhead abundance had increased. Brown trout growth was below the average for the Michigan area in populations coexisting with steelhead, but then exceeded the average when the associated cohort of steelhead migrated to sea.

Vincent (1987) found that the population of 2 year old and older brown trout increased 160% in both total numbers and biomass 4 years after stocking with catchable sized rainbow trout ceased. In addition, in a previously unstocked section, the numbers of 2+ and older brown trout decreased 49% in number and biomass when stocking was introduced. The impacts were limited to the numbers of older trout and there was no detectable impact on brown trout in their first 18 months of life. In addition, wild brown trout moved greater distances during periods of stocking and there was an increase in the susceptibility of these fish to angling pressure. The experimental design included a control section in the case of both the stocked and unstocked streams, for comparison of brown trout populations with the manipulated sections and thus this experiment provides some of the best evidence for an impact on rainbow trout stocking on adult brown trout.

Lakes

In lakes there have been much greater differences found in the types of food consumed by rainbow trout and brown trout that live sympatrically. Generally the difference is attributed to habitat differences, with rainbow trout tending to consume midwater prey, whilst brown trout consumed benthic prey or were more piscivorous (Idyll, 1942; Brown, Oldham & Warlow, 1980; Albertova, 1978, 1982; Warlow & Oldham, 1982; Lucas, 1993), although some authors found dietary overlap between the two species at certain times of the year (Brandt, 1985; McCarter, 1986; Lucas, 1993).

The greater tendency to piscivorous predation by brown trout may impact on rainbow trout juveniles and these have been shown to be susceptible to predation from brown trout in lakes where they inhabit inshore areas. In the presence of predators they look for areas with cover i.e. dense weed growths and avoid open areas (Tabor & Wurtsbaugh, 1991)

2.5.6 Predation

Examples of predation amongst salmonids have been reported in the literature, although there are few examples of rainbow trout predation on native salmonids in this country and where there has been evidence, there has been no attempt to assess the impacts on predated species populations.

Fausch & White (1981) reported brown trout predating on brook trout and partially blamed this for the decline of brook trout populations. Rainbow trout have been found predating on downstream migrating fry of Sockeye salmon (Ginetz & Larkin, 1976; Swartzman & Beauchamp, 1990), juvenile chum salmon (Fresh & Schroder, 1987), and Pacific salmon eggs accounted for 90% of the October diet of juvenile steelhead in a tributary of Lake Ontario (Johnson & Ringler, 1979).

2.5.7 Disease

Data on the transmission of disease from stocked fish to wild populations is very sparse.

Munro, Liversedge & Elson, (1976) demonstrated that infectious pancreatic necrosis (IPN) virus could be transferred to native brown trout and Atlantic salmon in Loch Awe. However, its prevalence was very low and the lack of any clinical signs in the infected fish suggested that this virus posed little threat.

IPN virus has been isolated from rainbow trout imported into China for farming (Jiang & Li, 1987).

Viral haemorrhagic septicaemia (VHS) can produce high losses in farmed rainbow trout. Recently natural outbreaks have been detected in brown trout (DeKinkelin & Le Berre, 1977), in pike (Meier & Jorgensen, 1979) grayling (Wizigmann, Baath & Hoffman, 1980) and coregonids (Meier, Ahne & Joergensen, 1986) although no author suggests that these natural outbreaks are linked to fish farms.

Whirling disease is a communicable disease of the salmonid family caused by the myxosporean *Myxobolus cerebralis*. Transfer of salmonids from unknown locations is restricted to prevent spread of this disease (Markiw, 1992).

2.5.8 Hybridisation

Hybridization is rarely discussed as a potential threat to native salmonids in this country. However, the introduction of an alien species beyond its natural range may result in hybridization with native species (Hindar & Balstad, 1994) and transplantations of rainbow trout in North America have led to introgressive hybridization with at least three other native salmonid species (Rinne & Minckley, 1985; Allendorf & Leary, 1988; Dowling & Childs, 1992; Carmichael *et al.*, 1993).

There is one record of a hybrid brown and rainbow trout occurring naturally in Kenya, where the spawning season of the two species coincided (Copley & Turing, 1938), but such events seem rare. Experimental crosses between brown trout and rainbows have not generally been successful and Worthington (1941) concluded that there was no danger of hybrids becoming established under natural conditions and this would seem likely so long as the spawning periods of the two species remain separated.

2.5.9 The impacts of rainbow trout on coarse fish

There is very little published literature on the impacts of rainbow trout on coarse fish populations. Predation by rainbow trout on juvenile cyprinids in water supply reservoirs is common (personal observation), but this does not appear to impact on these populations which continue to produce large numbers of fry each year. Similar predation on small coarse fish in America is not believed to affect recruitment of these species (Crossman, 1959).

Grossman *et al.* (1987) found no evidence of interspecific habitat shifts in a community of stream dwelling coarse fish containing rainbow trout.

Marrin & Erman (1982) found no evidence of food competition between rainbow trout and non-game fish in a reservoir in America.

2.6 Summary of the literature review

The rainbow trout is a polymorphous species which has thrived in most places where it has been introduced outside its natural range including North and South America, Europe, Africa, Asia and Australasia. In the British Isles, these introductions have often been very successful. At the population level, it has been observed that, at least in some European river systems, rainbow trout can have a dramatic impact on brown trout stocks.

Throughout this century there has been a steady increase in the number of waters in the United Kingdom containing rainbow trout. Despite this, there are relatively few recorded instances of rainbow trout spawning although these are increasing. Most of these spawnings are nevertheless supported by annual stockings and there are very few documented records of truly self-sustaining populations. It is not known why this should be the case and the mechanisms behind the failure of rainbow trout to establish self-sustaining populations in the United Kingdom are not as yet understood although poor stock, competition with native salmonids and lack of suitable habitat have been suggested, mostly unsupported by evidence.

On other continents, where self-sustaining populations have become established, complex interactions with other salmonid species have arisen with the competitive outcomes apparently dependent on habitat type and availability - particularly with regard to spawning activity.

It is not known what the threshold population level needs to be before rainbow trout are likely to become self-sustaining.

Although many places where rainbow trout are present in large numbers appear to have a suitable habitat, it is clear that the precise habitat requirements for these fish are not known although geology, temperature, hydrology and cover are believed to be critical factors.

Impacts on native salmonids (brown trout, Atlantic salmon and Arctic charr) could arise through, competition, hybridisation, predation and disease but very little evidence of such interactions exists. The most quoted reasons for the lack of self-sustaining populations of rainbow trout in the British Isles are 1) the use of all female, sterile or triploid stock, 2) reduced genetic variation from farmed stock so that the survival chance of progeny is reduced and 3) competition from earlier hatching brown trout.

Although the habitat requirements for spawning are similar to salmon, there is no published information of rainbows overcutting salmon redds. Indeed, most documented evidence shows that rainbow spawning does not take place at major salmon spawning sites. Rainbows also have limited impact on salmon in the early stages as the juveniles prefer slower flows than salmon juveniles. Where rainbows are abundant, they overcut brown trout redds in situations where spawning sites are limited and there is documented evidence of overcutting by rainbows although brown trout subsequently outcompete rainbows in their early stages.

Most studies of competitive interactions between rainbow trout and native salmonids have been conducted under controlled laboratory conditions and concentrate on the early life stages. It is known that at high velocities, rainbow trout are dominant over brown trout and the two species have been demonstrated to be variously dominant over one another dependent on size, habitat availability, water velocity and temperature. There is insufficient data to draw any conclusions on relative dominance which can be transferred to the natural environment.

The American literature shows that rainbows predate on several species of salmonids but no such evidence is documented in the literature for the British Isles.

There are few instances where diseases have been shown to be transmitted from farmed rainbow trout to wild fish but potentially this could occur.

The risk of hybridisation between rainbow trout and native salmons in this country would seem to be minimal.

3. REVIEW OF AGENCY DATA

3.1 Introduction

A letter requesting data from the regions was sent out to all Area FRCN managers in each Region. This was considered to be the most cost effective method of arriving at a general overview of the amount and quality of data held in the Agency regions. Copies of the letter were sent to Regional FRCN Managers to keep them informed of the project. A copy of the letter sent is presented in Appendix 1. Information was requested on

1) Impacts of rainbow trout on resident salmonid populations
2) Details of local Agency policy on stocking
3) Details of stocking practices
4) Data on historical introductions of rainbow trout
5) Data on self-sustaining populations
6) Known or perceived risks of stocking
7) Data on escapes of rainbow trout into the wild

Several of these are dealt with elsewhere in the report. This section concentrates on reviewing Agency data on impacts of rainbow trout on resident salmonid populations, historical introductions and details of stocking practices.

3.2 Results

As expected, the quantity and quality of data varied considerably between Regions. In general, it was apparent that it was difficult and time consuming to extract relevant information that was collected during the rolling stock programmes. Data storage differed between the regions with some able to produce data from computer whilst others relied on paper copy. Much information requested resulted in opinions of Fisheries staff based on their experiences rather than hard evidence. This was understandable as few studies have been carried out on rainbow trout alone. Details of stocking practices varied. Many Regions sent raw data in the form of Section 30 consents and these varied from photocopies of originals to computer printouts. Data from these sources were difficult to compare due to the different practices of the regions. Blanket permissions were given to some clubs in some Areas to introduce fish throughout the year which makes comparisons of stocking practices between seasons inaccurate. Other difficulties were due to the quality of the data recorded; from numbers of fish, lengths of fish (inches or cm), weights (pounds or grammes) and even mixtures eg from 6 inches to 5 lb. Some even say "various" or "mixture". Information was also sent for a varying number of years. In view of the fact that WRC have produced a comprehensive report reviewing Section 30 consents, this report covers only the current stocking practices in the regions as detailed in 1994 and 1995 Section 30s where available.

3.2.1 Section 30 data

Annual figures for introductions of rainbow trout are given for many areas of most of the Agency Regions (Table 1, Fig 1). In all Areas where comparable data exists, the number of introductions into still waters is very much larger than the number stocked into running waters. Hundreds of thousands are released annually into still waters in many Regions (Welsh, North West, Thames, Midlands and Anglian) and it is likely that large numbers are released in the Regions where data are not available. Introductions into rivers are generally modest in comparison (Fig 2) and are likely to be lower than occurred in previous years, given that many areas actively discourage or ban introductions entirely. North East are phasing out introductions into rivers and at present only industrial lowland rivers or others with a history of introductions are stocked. Both North West and Anglian have little in the way of introductions into rivers. Thames Region stock rivers reasonably heavily with over 10,000 being introduced into the West Area and a similar number are stocked in the North Wessex Area of South West Region. Introductions into salmon rivers are common in the Hampshire Area of Southern Region accounting for the high percentage (> 30%) of rainbows stocked into rivers in 1994 in that Region (Fig 2). Numbers have increased from 2465 in 1994 to 6265 in 1995 in that Area. These fish are often very large and are likely to be piscivorous consuming juvenile salmon (possibly both parr and smolts). This needs quantifying in that salmon populations in chalk streams are declining, particularly in the R. Test where many of these fish are stocked. Whilst rainbows may take only a small percentage of the juvenile salmonids it must be asked whether any loss is acceptable at the current time.

Data was split into four seasons, Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec and into small and large fish (Table 2, Figs 3 and 4). The definition of size was < or > 25 cm in length or 450 g in weight. Of the data available, most fish introduced to rivers were of a large size (Fig 3) except for Thames West were a significant proportion of small fish were stocked (approx one third in 1995). Generally, fish are introduced at a size large enough for angling. This is also true for still waters (Fig 4). At this size, they may compete for space (ie territories) with natural salmonids and are also capable of piscivory. Small fish, usually stocked at high density, are more likely to compete with native juveniles. This may not have been a problem in the Thames Region where no natural salmon populations have existed for some time but the effect should be assessed in the R. Thames and its tributaries where salmon are being encouraged to return.

A high proportion of the stocked fish are introduced into rivers in January - March ie before the trout season starts. Further introductions are normally made throughout the season and in Thames, introductions are even made into rivers in October - December. In still waters, although large numbers of fish are introduced before the season, there is a regular introduction throughout the season presumably to replace taken fish.

Table 1 Annual introductions of rainbow trout (* = information not available)

Region	*Area*	*Year*	*Rivers*	*Stillwaters*
Anglian	Essex	1994	8500	66,626
	Eastern	1994	0	0
	Central	1994	0	120,200
	Lincoln	1994	0	28,733
	W&N	1994	0	198,835
	Norf&Suff	1994	0	22,841
North West	Central	1994	0	64,327
		1995	0	68,000
	Northern	1994	0	856,608
Midlands	Upper T	1994	0	19,146
		1995	1,474	90,646
	Upper S	1995	1150	35,000
Southern	Sussex	1994	1195	14846
		1995	1185	13976
	Kent	1994	4190	*
	Hampshire	1994	2465	*
		1995	6265	*
South West	N Wessex	1994	690	*
		1995	10725	*
Thames	NE	1994	1185	27,760
		1995	890	77,595
	SE	1994	750	160,284
		1995	2539	80,749
	W	1994	5314	65,924
		1995	11,980	63,525
Welsh	SW	1994	7,760	400,000
	Northern	Jly94-Aug95	1,419	*

Table 2 Seasonal introductions of rainbow trout (* = information not available)

Size definition is < or > 25 cm in length or 450 g in weight

Region	Area	Month of introduction	Number of fish			
			Rivers		Lakes	
			Small fish	Large fish	Small fish	Large fish
Midland	Upper Trent	Jan-Mar	0	0	0	2550
		Apr-Jun	0	0	0	8090
		Jul-Sep	0	0	0	7706
		Oct-Dec	0	0	0	800
		TOTAL 94	**0**	**0**	**0**	**19146**
		Jan-Mar	0	212	0	24100
		Apr-Jun	0	962	0	28478
		Jul-Sep	0	300	0	22718
		Oct-Dec	0	0	0	15350
		TOTAL 95	**0**	**1474**	**0**	**90646**
Southern	Sussex	Jan-Mar	0	0	0	12430
		Apr-Jun	0	1195	0	1312
		Jul-Sep	0	100	0	1031
		Oct-Dec	0	0	0	150
		TOTAL 94	0	1195	0	14923
		Jan-Mar	0	500	0	4390
		Apr-Jun	0	325	0	5616
		Jul-Sep	0	360	0	3970
		Oct-Dec	0	0	0	0
		TOTAL 95	0	1185	0	13976
Southern	Kent	Jan-Mar	0	260	*	*
		Apr-Jun	0	2680	*	*
		Jul-Sep	0	1250	*	*
		Oct-Dec	0	0	*	*
		TOTAL 94	**0**	**4190**	*	*
Southern	Hampshire	**Feb-Mar 94**	**0**	**2465**	*	*
		Feb-Mar 95	**0**	**6265**	*	*
South West	N. Wessex	Jan-Mar	0	500	*	*
		Apr-Jun	0	190	*	*
		Jul-Sep	0	0	*	*
		Oct-Dec	0	0	*	*
		TOTAL 94	**0**	**690**	*	*
		Jan-Mar	0	9875	*	*
		Apr-Jun	0	850	*	*
		Jul-Sep	0	0	*	*
		TOTAL J-S 95	**0**	**10725**	*	*

Table 2 continued

Region	Area	Month of introduction	Number of fish			
			Rivers		Lakes	
			Small fish	Large fish	Small fish	Large fish
Thames	NE	Jan-Mar	0	0	0	0
		Apr-Jun	0	800	0	7850
		Jul-Sep	0	175	0	16900
		Oct-Dec	0	210	1650	1360
		TOTAL 94	**0**	**1185**	**1650**	**26110**
Thames	NE	Jan-Mar	0	40	3400	57695
		Apr-Jun	0	725	0	12900
		Jul-Sep	0	125	3000	600
		TOTAL J-S 95	**0**	**890**	**6400**	**71195**
Thames	W	Jan-Mar	0	2950	0	51704
		Apr-Jun	0	1764	0	5720
		Jul-Sep	600	0	0	2050
		Oct-Dec	0	0	3200	3250
		TOTAL 94	**600**	**4714**	**3200**	**62724**
		Jan-Mar	1800	4630	0	61845
		Apr-Jun	600	3575	100	500
		Jul-Sep	150	0	0	155
		Oct-Dec	1200	25	0	925
		TOTAL 95	**3750**	**8230**	**100**	**63425**
Welsh	Northern	Jul-Sep	0	230	*	*
		Oct-Dec	0	0	*	*
		TOTAL Jul-Dec 94	**0**	**230**	*	*
		Jan-Mar	0	928	*	*
		Apr-Jun	0	151	*	*
		Jul-Sep	0	110	*	*
		TOTAL J-S 95	**0**	**1189**	*	*
Welsh	SW	Jan-Mar	0	250	750	67916
		Apr-Jun	0	2441	11200	93539
		Jul-Sep	0	1476	0	54346
		TOTAL J-S 95	**0**	**4167**	**11950**	**215801**

Fig 1 Annual introductions of rainbow trout in 1994

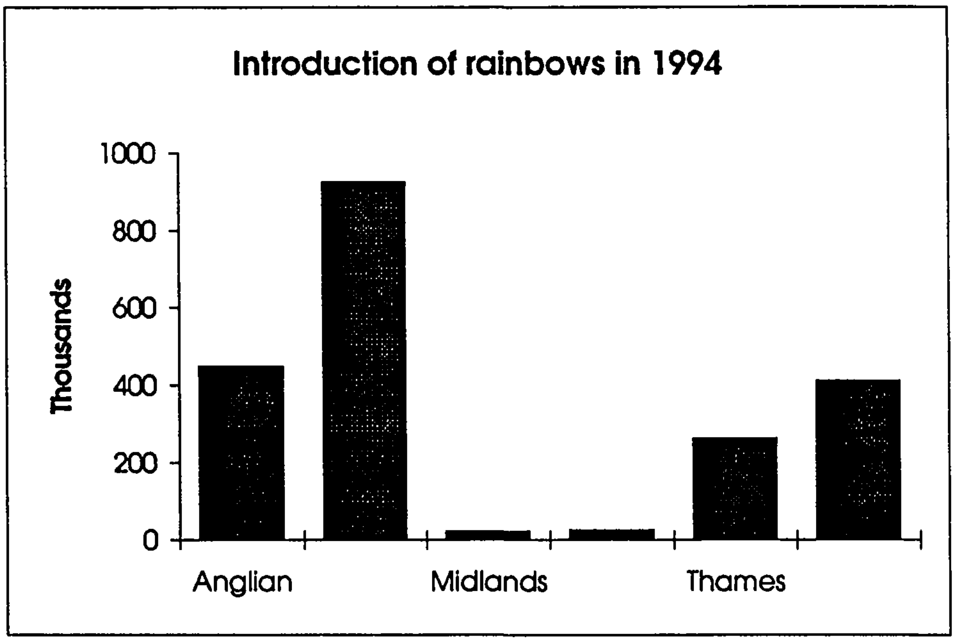


Fig 2 Proportion of rainbow trout stocked into rivers rather than still waters in 1994

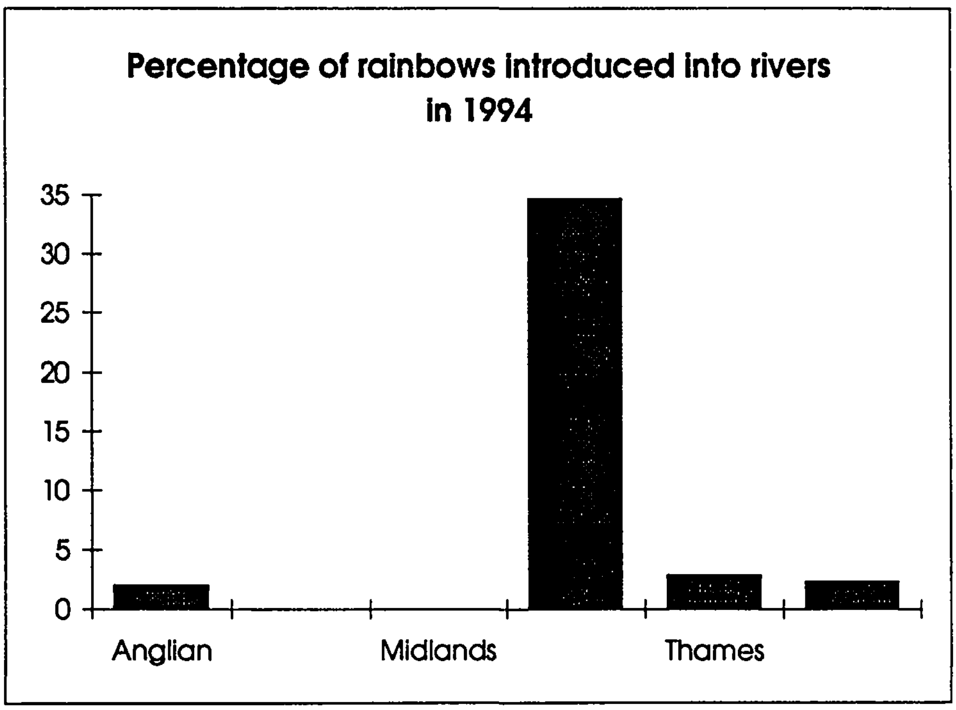


Fig 3 **Seasonal pattern of introduction of small (< 25 cm or < 450 g) and large rainow trout into rivers**

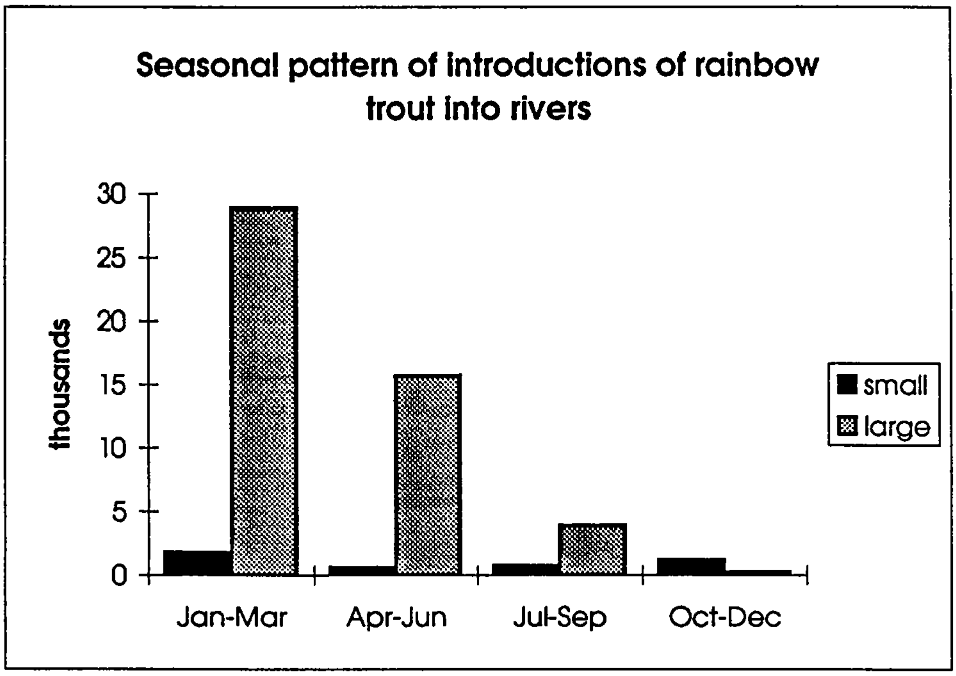
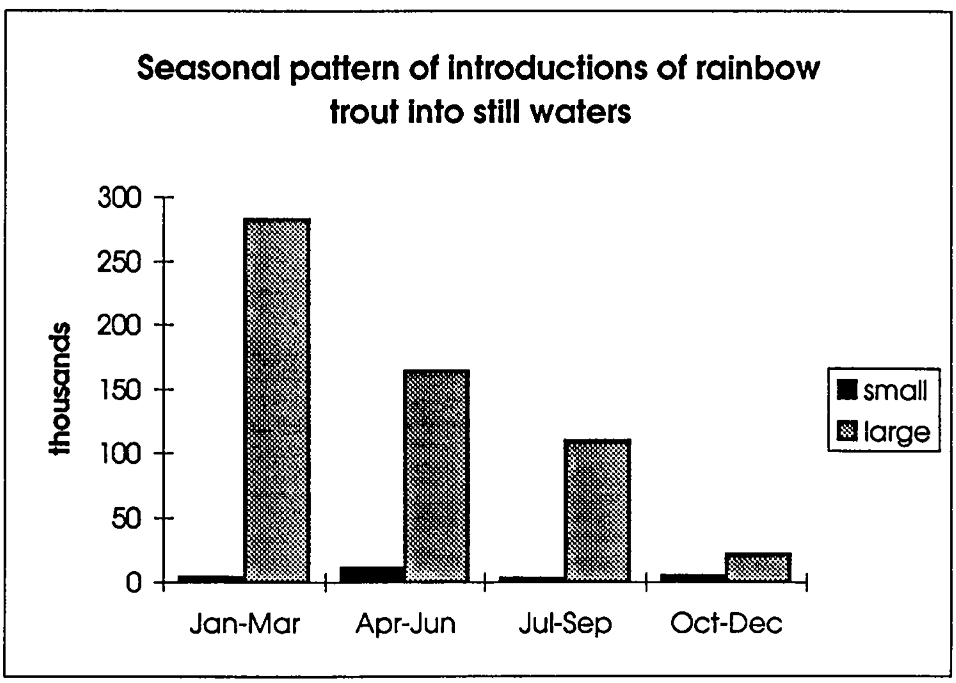


Fig 4 **Seasonal pattern of introduction of small (< 25 cm or < 450 g) and large rainbow trout into still waters**



3.2.2 Impacts of rainbow trout on resident salmonid populations

Very little Agency data exists on the impacts of rainbow trout on resident salmonid populations, however Northumbrian Water are funding a study on a population of rainbow trout in Carl Beck, a tributary of the upper Tees. Such Agency data that do exist are mainly based on subjective assessments following escapes from fish farms. Anglers complain of catching rainbow trout escapees and it can be concluded that these escapees cause a deleterious although short term impact on the fishing.

Subjective assessments have been made in several Agency regions by Fisheries staff. In Thames (South East), there is an almost continuous small scale escape of rainbow trout with no noticeable effect. Even where escapees have attempted to spawn, (Welsh (South Western)), no impact on the natural salmonids has been evident. The same is true for many rivers where rainbow trout are stocked. In the South Wessex Area of South Western Region, historical introductions over many years have shown no known impact on the brown trout populations.

Hard data exists from the Devon Area of South Western where stomach content analysis has shown that rainbow trout eat juvenile salmonids although there is no direct evidence of an impact at the population level. In Esthwaite Water (North West), 6lb rainbows have been observed eating fry (most probably of coarse fish).

No experimentation has been attempted to show the impact of rainbows on a fishery. However, Welsh (South Western) sampled a catchment one year after a large escape to determine the effect on the fishery. This area has produced a report entitled 'A report on the studies into the effects on native salmonid stocks of two large scale escapes of rainbow trout in the Cleddau catchment' (Whightman 1988). There were two large escapes of rainbow trout parr (180000) and adults (unknown number) in the Cleddau catchment in August 1986 and surveys in June and July 1987 were undertaken to determine whether there had been a deleterious effect on the native salmonid population. The surveys caught no adult rainbows and only small numbers of parr at two sites. Although late cut redds were observed in Jan-Feb 1987, large numbers of salmon fry were subsequently found in these areas. Rainbow trout fry were found in small numbers at only one site indicating very limited spawning success. Although no stomach content analyses were performed, very high densities of native salmonids were found where adult rainbow trout were observed to have congregated in 1986. The conclusion of the report was that there was no cause to suspect that significant predation had occurred or that there had been any adverse impact of the escapees on native fish. The vast majority of these escapees had left the freshwater system within the year. The fact that rainbow parr were only found at sites with very low densities of native salmonids could indicate that the escapees could not compete and were displaced into sub-optimal habitats. Observations by bailiffs during routine monitoring have also given the impression that there is no impact of rainbow trout on native salmonids.

Rainbow trout have been introduced to the R. Box (Anglian, Essex Area), for over 20 years. These introductions remain in the reach presumably due to sluices/weirs associated with a mill immediately downstream. Brown trout are also introduced and there is a small spawning population although it is not known whether these are native or introduced stock. Efforts have been made to create a trout fishery here by removal of coarse fish but this has not been achieved and coarse fish are still numerically dominant. It is reasonable to conclude that the rainbow trout are not having any impact on the coarse fish populations.

In Anglian (Central) escapes into the R. Nar, a SSSI have produced no adverse impact.

3.2.3 Historical introductions

Very little data has been sent on this topic mainly because Section 30 forms are a relatively recent introduction. Information may exist within Agency offices but in a diverse form which is time consuming to collate. No Agency staff suggested that they had any worthwhile information on this subject. General information that exists in the literature is documented in the review. Some angling club records may provide a better historical picture but again, extra work to collate this will be required and identification of these clubs will only be possible with the co-operation of the Agency.

3.3 Review of Agency data from selected areas

3.3.1 Introduction

It was financially prohibitive to visit and review the reports on fisheries surveys from all areas. Therefore six area offices were selected primarily on the basis of the quantity of stocking of rainbow trout and the reported presence of spawning or self-sustaining populations. The following offices were visited during January 1996:

South West Region	North Wessex
South West Region	South Wessex
Southern Region	Hampshire
Southern Region	Kent
Thames Region	West
Midlands Region	Lower Trent

As the data for fishery stock surveys were not collected with this review in mind, much of it was irrelevant. Furthermore, in comparison to the amount of water available for survey only a very small proportion has been surveyed, with the effect that very few fish tended to be caught. It was not possible in most cases to put together time series analyses as at best any one site has only been surveyed twice since the inception of the then NRA. Reports of previous surveys completed by preceding organisations were often unavailable, or where they were available the surveys tended to be qualitative rather than quantitative.

3.3.2 North Wessex - South West Region

Surveys of three catchments were relevant to this review, these being the Doniford Stream, the River Biss catchment and the streams running into Chew Valley Lake.

The Doniford stream including the Monksilver stream had been surveyed in 1983 and again in 1994. Five sites were surveyed in 1983 and eight in 1994. Although five sites fished in 1994 coincided with sites fished in 1983 they were not directly comparable to those fished in 1983 as the lengths of river and areas fished differed between the two times. The report itself does not contain raw data but provides graphs of the density of all fish species found. In 1994, two of the eight sites contained rainbow trout. The brown trout populations in these sites were below the average of all eight sites, but there were also two sites that had lower brown trout densities.

One site was surveyed on the River Biss in 1989 and 1993. Rainbow trout, assumed from their appearance to be the offspring of wild spawning, were found at the site in 1989. Based on a total of seven fish captured, their density was almost three times that of brown trout. In 1993, no rainbow trout were captured and this was thought to have been due to a pollution occurring between the two surveys. Three adult brown trout were captured at this site in 1993, but no juveniles were present.

The River Chew above Chew Valley Lake was surveyed in 1991 and 1995. In 1994 another tributary of Chew Valley Lake, the Hollow Brook was surveyed. Chew Valley Lake is stocked with both rainbow and brown trout. In 1991, three adult rainbow trout were found in the River Chew and there were 80 brown trout captured representing a density of 630 brown trout per hectare, many of these being juveniles. In 1995, five smaller rainbow trout were captured and these were assumed from their appearance to have been wild spawned fish. However, there was no significant change in the number of brown trout present and they are still numerically dominant in this stream. In the Hollow Brook, brown trout predominated over rainbow trout, in a ratio of three to one, but the two rainbow trout captured were thought from their small size and appearance to be wild spawned fish.

3.3.3 South Wessex - South West Region

The annual juvenile salmonid surveys of the catchments in this Area are relevant to this review. Each year from 1988 to 1992 a total of 12 sites were surveyed on the River Frome, 10 on the River Piddle and 13 on the River Avon. On each survey, the biomass of salmon and trout juveniles were estimated. The presence of rainbow trout was noted although there is no information on the population structure of this species. In all these sites, rainbow trout were only noted on one site on the River Piddle each year and on one occasion on a site on the River Avon. The density of juvenile salmon and brown trout on the River Piddle site with rainbow trout were consistently above the average for the sites on the River Piddle which did not contain rainbow trout. The exception to this was in 1992 when the density of salmon was very low in the site with rainbow trout.

Since 1993 the number of sites surveyed has increased to 61 on the River Frome, 28 on the River Crane, 59 on the River Allen and 76 on the River Piddle. Rainbow trout are not observed on the River Allen and are found very infrequently on the River Frome and River Crane. They are found more commonly in the River Piddle; at 9 sites in 1993, 14 sites in 1994 and 5 sites in 1995. However, there is no detectable depression in the density or biomass of salmon and brown trout in sites with rainbow trout and the density of rainbow trout found was usually low. Although there is no information on the population structure of the rainbow trout; in 1994 there was an impression from fisheries staff that some of those found were young of the year and since these are not known to be stocked were potentially the result of wild spawning of rainbow trout.

3.3.4 Hampshire - Southern Region

Fish stock surveys of the River Test, River Anton, Bourne Rivulet and Pillhill Brook are relevant to this review. A survey of the R. Test was made in 1992 and of the other three catchments in 1994.

Eleven sites were surveyed on the River Test. Six of these sites contained rainbow trout, but only one had them in significant numbers. The numbers and density of brown trout in these sites were supported by stocking and therefore any impacts on this species cannot be determined from the data. The number and density of juvenile salmon at sites inhabited by rainbows was lower than the average number of juvenile salmon found at all sites combined. Two sites were surveyed on the Bourne Rivulet, one of which had rainbow trout and one that did not. The site with rainbow trout had a greater number and density of brown trout. Two sites were surveyed on the River Anton, one of which had rainbow trout and one that did not. The site without rainbow trout had a greater density of brown trout than the site with rainbow trout and it also contained salmon juveniles which were absent from the site with rainbow trout. The one site surveyed on the Pillhill Brook had small numbers of rainbow trout as well as a not unusual population of brown trout.

3.3.5 Kent - Southern Region

Although initial replies to enquiries from this area stated that there was a spawning population of rainbow trout in the River Len there was no data available at the office. In previous fishery surveys, rainbow trout were found in the River Teise in 1994 and in the River Medway in 1992.

Only one site was surveyed in the River Teise where a total of two rainbow trout and one brown trout was found. Of four sites surveyed on the River Medway, only one contained rainbow trout and this also had the greatest number of brown trout.

3.3.6 West - Thames Region

Fish stock surveys have been completed at six sites on the River Kennet, River Windrush and River Dikler during 1993 and 1994. Rainbow trout were found at all sites but always at very low numbers. There were much higher numbers of brown trout at all these sites, although these are probably supported by stocking.

Much greater numbers of rainbow trout have been found at three sites surveyed on the River Coln and River Dun during 1991, 1992 and 1995 and at all these sites the numbers of brown trout were low.

3.3.7 Lower Trent - Midlands Region

Fish stock surveys relevant to this review include a survey of 12 sites of the River Derwent in 1992 and 1993 and surveys of two sites on the River Wye in 1991 which has the best known and longest lasting of the supposed self-sustaining populations of rainbow trout in England.

Of the sites surveyed on the Derwent, four contained rainbow trout all of which were large fish. The numbers and densities of brown trout in these sites were similar to those of the sites where rainbow trout were not present.

Although rainbow trout were found at both sites surveyed on the River Wye, at only one did the surveyor state that there appeared to be natural recruitment at this site. There was only one occasion when this site was sampled. However, enough fish of both brown trout and rainbow trout were caught to make some comparison of two year classes of both species. From this small amount of data it appeared that a weak year class of brown trout (1991) coincided with a strong year class of rainbow trout. In the previous year (1990) there was a stronger year class of brown trout which coincided with a weaker year class of rainbow trout. To confirm such an observation, this population would need to be studied over a greater time period.

3.3.8 Discussion

Although there were occasionally examples of lower numbers or densities of native salmonids in the presence of rainbow trout, there were as many examples where the density of native salmonids was greater in sites with rainbow trout. It is probable that the number of native salmonids at any one site is more greatly affected by other factors such as habitat, or stocking practices, than by the presence of rainbow trout and therefore any impact of stocked or wild rainbow trout populations is masked by these differences when comparing sites. The use of HABSCORE as used in the study of the effects of stocked brown trout on the survival of wild fish populations (R&D Note 490) may be useful to quantify the effects of habitat differences between sites so that impacts can be more readily assessed.

Alternatively, the performance of controlled experiments where inter-site differences are minimal or distributed randomly through the experimental design, together with long-term time series analysis of a few select sites would provide more useful data. Unfortunately, many of the survey sites in the rolling survey programme are often selected at intervals of several kilometres from one another and this leads to a great difference in habitat between them, such that they do not approach controlled experiments. There were few examples where one site had been surveyed more than once, in a directly comparable way, and often the limited size of the site surveyed meant that low numbers of fish were captured making it difficult to draw conclusions from any time series analysis.

The most interesting piece of data came from one site on the River Wye, where sufficient fish had been captured to make some comparison of year-class strengths, although the use of only two year-classes means that the possibility of coincidence cannot be discounted. This emphasises the importance of completing a longer term study at a few sites to demonstrate the presence of any impact and more importantly the mechanisms behind it.

4. ENVIRONMENT AGENCY STOCKING POLICY

4.1 Introduction

The rainbow trout is a non-endemic species (as defined by the Wildlife and Countryside Act 1981) and as such it would not be normal to consent to its introduction. However, in 1982, both MAFF and the Welsh Office waived its non-endemic status under General License issued in accordance with sections 16(4) and (5) of the 1981 Act. It is still a requirement for Section 30 consent to be obtained before introductions can be made.

4.2 Methods

A letter (Appendix 2) was sent to each Regional FRCN Manager requesting details of stocking policy.

4.3 Results

Replies vary in detail. Information asked for on existing practices was usually brief but managers did offer to discuss the matter further if necessary. This would require further time either on the telephone or for visits. Some supplementary information on policy and practices has been received from Area Managers as part of their response to the letter sent. The policy of individual Regions is set out below.

4.3.1 Welsh Region

Detailed debate at RFAC meetings in Wales on the possible effects of introductions of rainbow trout have led directly to this project. Consents to stocking were being granted by the Agency under Section 30 of 1975 Salmon and Freshwater Fisheries Act and the Wye salmon fishing interests challenged these. It became apparent that there was little or no evidence that these introductions have a deleterious impact on the receiving watercourse especially given the fact that the species rarely reproduces in the wild in Great Britain.

Over the course of a year, three papers were presented to the Welsh RFAC;

1. 'Introduction of Non-Indigenous Fish Species' by Alan Winstone, Senior Fisheries Scientist
2. 'Introduction of Alien Fish Species to Welsh Rivers' by Garry Jones, Fisheries Scientist
3. 'Trout Stocking - A Discussion Paper' by Warwick Ayton, Regional FRCN Manager

1. 'Introduction of Non-Indigenous Fish Species'

The first paper reviewed the historical perspective of introductions of non-indigenous fish species and covered the legislation governing these introductions. The paper recommended that the Agency would generally be against the introduction of non-indigenous fish species (defined locally as one not ordinarily resident in the water body) into the rivers of the Welsh Region, and that any proposed stocking which had the backing of the Agency would first be referred to the Local Fisheries Group for their advice. For stillwaters, stocking would be carried out on a case by case basis following an assessment of the likely impact upon native populations and the likelihood of escapes.

2. 'Introduction of Alien Fish Species to Welsh Rivers'

This paper reviewed the level of stocking of, among others, rainbow trout into waters of the Welsh region. Figures are given for introductions in 1993. Following the recommendations of the first paper, introductions were mainly to still waters with 385,000 fish stocked in the size range 7-14 inches. In comparison, only 5645 fish were introduced to rivers, these rivers being mainly in industrial areas where pollution events had reduced fish stocks. The paper lists one benefit of the introduction of rainbow trout over brown trout in running waters. This is that rainbow trout rarely breed in these conditions and no inter species breeding takes place so there is little impact on the breeding of resident salmonids. Compared to this, the introduction of hatchery reared brown trout may adversely affect the genetic integrity of the resident wild population.

The paper then discussed the impact of rainbow trout on native fish populations, concluding there was no evidence for adverse impacts in the UK, with rainbow trout likely to disperse from the stocking location to such an extent as to have largely left freshwater by the following year.

The paper recommended that rainbow trout were not considered non-indigenous and that applications for introductions would continue to be screened by the District Fisheries Managers. However, the RFAC did not support the continued stocking of rainbow trout into rivers as recommended in this paper and a third paper set out the Agency Welsh Region's interim position, pending the results of commissioned R&D on the subject.

3. 'Trout Stocking - A Discussion Paper'

The background is again presented in this paper. It concluded that it is impractical to consult local or regional committees before consenting to Section 30 applications as applicants require a quick response. Each application will be critically assessed by District FRCN Managers who are considered to have the necessary experience and technical expertise and the relevant committees will be informed of their decision at future meetings. The paper points out that refusal to issue Section 30s have to be supportable if challenged and that widespread refusal would be cause for concern to the fish farming industry.

4.3.2 North West Region

There is no written policy on the introduction of rainbow trout but there is an informal policy for Area Fisheries Managers not to issue Section 30s for running waters. Still waters are, however, stocked.

4.3.3 North East Region

Before the merger of these two regions, there were different policies with Yorkshire Region consenting to introductions into rivers and Northumbria Region refusing permission except under special circumstances. Since the merger, there has been a requirement for a common policy. The policy on the introduction into still waters remains unchanged. Stocking continues to be allowed with the appropriate Section 30 consents. In rivers, the current policy is that introductions of rainbow trout will only be permitted where historic introductions have previously taken place. It is intended to eventually phase out introductions into rivers.

4.3.4 Anglian Region

Again there is no formal policy relating to introductions either into enclosed or open systems. A number of rivers within the Region receive annual stocking of rainbow trout although the number of rivers affected is low. No rivers in the Eastern or Central Areas are stocked. Stocking with brown trout is encouraged because it is a native fish species. Very large numbers of trout, mainly rainbows, (total >400,000) are stocked into reservoirs.

4.3.5 South West Region

This Region had a similar problem to North East Region in that it is a merger of two Regions, Wessex and South West and that these different Regions had different policies. Unlike North East Region, South West Region have not implemented a common policy across the region, preferring to wait for a national review on stocking policy. At present, Devon and Cornwall do not permit introductions into rivers but allow stocking of ponds, lakes and reservoirs with screening required if connected to watercourses to prevent escapes. In South Wessex, stocking of rivers is permitted but only a few rivers have been stocked. The current North Wessex policy is not to encourage rainbow stocking into rivers but consents would probably be granted if applications were received. This is contrary to the old Somerset Area where stocking in rivers was opposed but similar to the policy in the old Bristol Avon Area where rainbows have been historically introduced into the Bristol Avon and its tributaries.

4.3.6 Southern Region

There is no formal policy for this Region. Stocking is allowed in rivers in the Kent Area and is widespread in the Hampshire area although a more stringent policy has been employed since 1992. In contrast, in the Sussex Area, consent to stock rainbow trout is only granted where a long-standing programme is in place. All other applications are refused. This policy is to reduce brown and rainbow trout stocking into rivers.

4.3.7 Thames Region

The North East Area has no formal policy although it advises against introduction of rainbow trout if native brown trout are present, however, consent is always given to introductions if this advice is ignored. Staff in this area are now not so sure that this advice not to stock with rainbows is correct. Personal preference is for rainbows rather than "genetically polluting browns". The South East Area considers requests on merit but no applications have been refused. There is only one river in this Area that is regularly stocked. In the West area, each application is considered on merit. They actively encourage fisheries to move towards catch and release of native brown trout populations where conditions are suitable.

4.3.8 Midlands Region

In the Upper Severn Area, there is generally no restrictions on the stocking of stillwaters although they could be applied if they received applications for introductions into sensitive waters, eg SSSIs, upland lakes with pristine wild brown trout populations and Llyn Taru which contains a self-sustaining population of American brook trout. At present, stocking is allowed in rivers although advice is given on adopting alternative strategies. New applications are strongly discouraged and refusal will be considered for sensitive rivers. They adopt the precautionary principle and are likely to apply this increasingly in the future as stated in their Upper Severn and River Teme catchment management plan. In the Lower Severn Area, there is no local policy. It has been the normal practice to stock rainbows into the R. Derwent and it is considered to be impractical to change existing practices. The R. Wye (Derbyshire) is the only other river stocked. Most reservoirs receive rainbow trout each year. In the Upper Trent Area, introductions are made to both still and running waters although the introduction into running waters is actively discouraged especially in the R. Dove and its tributaries, the only system in this area with a good native trout population. Rainbows are stocked into the R. Blythe where few if any native fish occur.

4.3.9 Conclusion

There is no common policy across the Agency Regions concerning the introduction of rainbow trout into running waters although all Regions allow introductions into still waters. Even within Regions, different policies are implemented between Areas. There appears to be no basis of fact by which practices are judged, it is more a personal opinion of the officer involved. Interestingly, views are changing. Whereas it was becoming more common for areas to be taking a hard line on introductions into running waters, some have reviewed this and now allow the practice as there has been no hard evidence of an adverse impact on other resident fish populations. Most regions do not have a written policy and it is in these regions where different practices are carried out in the Areas. In Wales, the question has been discussed extensively in RFAC meetings and the current written policy is against a ban on introductions. In the newly reorganised regions (Northumbria and Yorkshire and South Western) the question of a common policy has been investigated. Northumbria and Yorkshire have agreed a common policy whilst South Western have decided to await the outcome of a national review.

5. SELF-SUSTAINING POPULATIONS OF RAINBOW TROUT

5.1 Introduction

Most Agency personnel judged 'self-sustaining' to mean evidence of successful spawning ie the existence of juveniles. Many only have anecdotal evidence (anglers' catches) but no hard data. Such data as does exist is not usually site specific but refers to rivers or tributaries in general. Maps showing these rivers are given in Fig 1. In this report, a self-sustaining population is defined as one which can persist naturally for several generations ie where a population spawns successfully producing viable offspring which in turn mature and spawn successfully. Populations may persist for several generations but only with repeated stocking. These populations are not considered to be self-sustaining.

5.2 Results

There appear to be only two rivers where a truly self-sustaining population exists. In the Derbyshire Wye, this population has existed for many years. It was referred to in the literature as early as 1930 (Tew 1930) and in the surveys by Worthington (1941) and Frost (1974). The second is in Carl Beck, a tributary of the R. Lune in the Tees catchment in North East England. This population is being studied by Dr D.T.Crisp under a grant from Northumbria Water. Rainbow trout fry from natural breeding were found in the upper Welsh Wye in 1995 and 1996. They were the result of an intensive stocking of large rainbows which were kept in place by pellet feeding and as such cannot be considered to be truly self-sustaining.

Other references from Agency Fisheries staff are to cases where spawning has been observed or the presence of juvenile rainbows has been demonstrated presumably the result of spawning. For example, rainbows are breeding very successfully (thousands of fry) in Black Beck, a tributary of Esthwaite Water but presumably as a result of regular stocking of the lake. In addition, there is anecdotal evidence, mainly from anglers, in cases where juveniles have been caught. All these are indicated on the maps.

Further, one off spawning events have occurred occasionally. For example, rainbow trout bred successfully after an escape in the R. Lyd, a tributary of the R. Tamar in 1971 or 1972 and rainbows paired up in the St Neots river after an escape into the R. Fowey although no juveniles were found. Both these examples are in the South West Region of the Agency.

5.3 Conclusion

Although the conditions quoted in the literature for the successful spawning and sustainability of rainbow trout seem to be present in many areas of the UK, there are only two instances of truly self-sustaining populations. This situation is contrary to that occurring in other countries. Rainbows in the USA, New Zealand and on the Continent in the Alpine Rhine Valley have shown that they are capable of creating self-sustaining populations in rivers to which they have been introduced. Notably, in the Rhine valley, rainbows have spread into neighbouring tributaries which had not previously been stocked. This work was given as a personal communication, the work is ongoing and papers are in preparation. These will be vital papers in assessing the potential for rainbows to become self-sustaining in the UK. In the UK, it may be that the production and introduction of all female stock has limited the ability of rainbow trout to spawn successfully and establish self-sustaining populations.

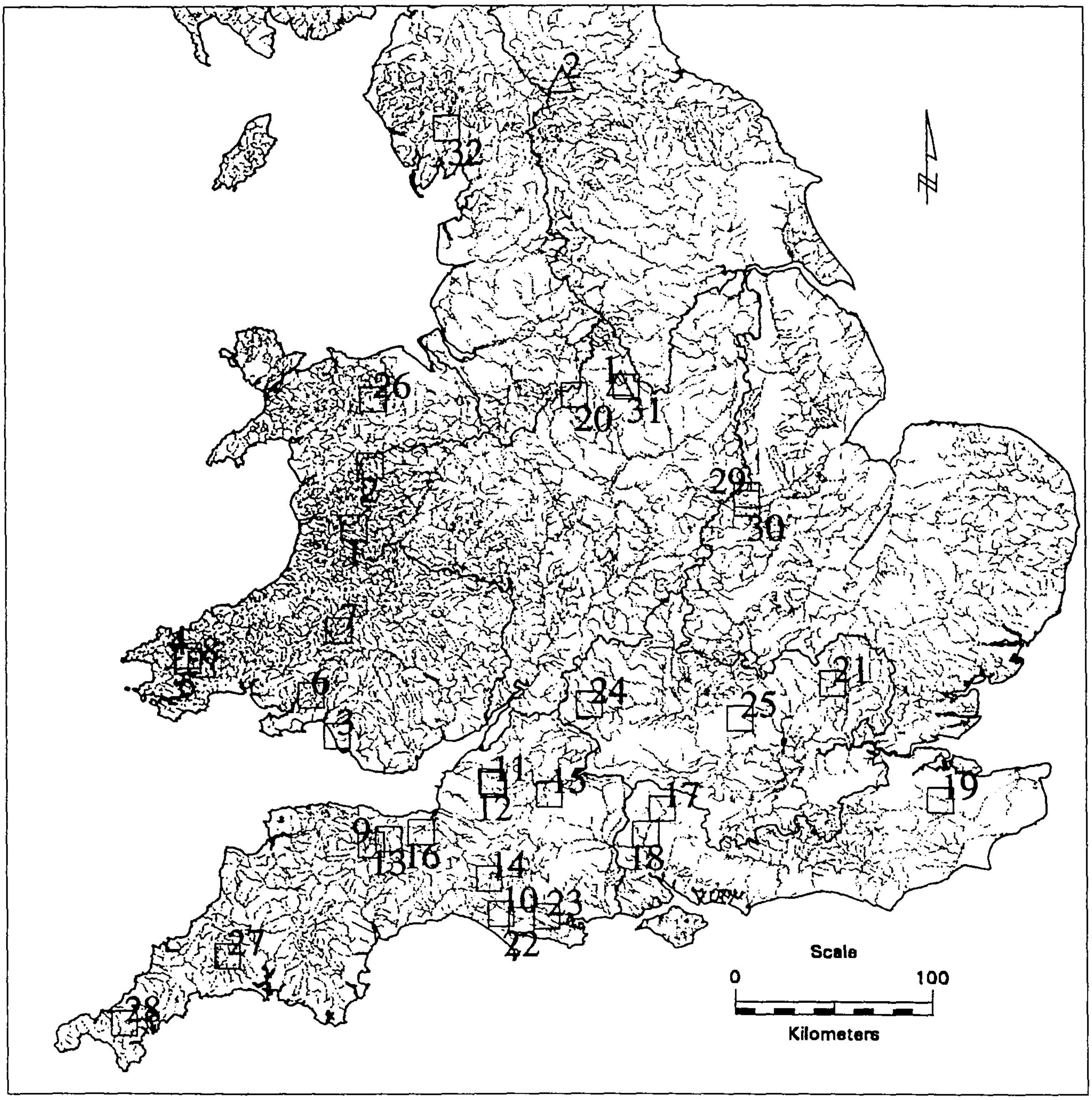
Fig 5 Maps showing known self-sustaining and spawning populations of rainbow trout

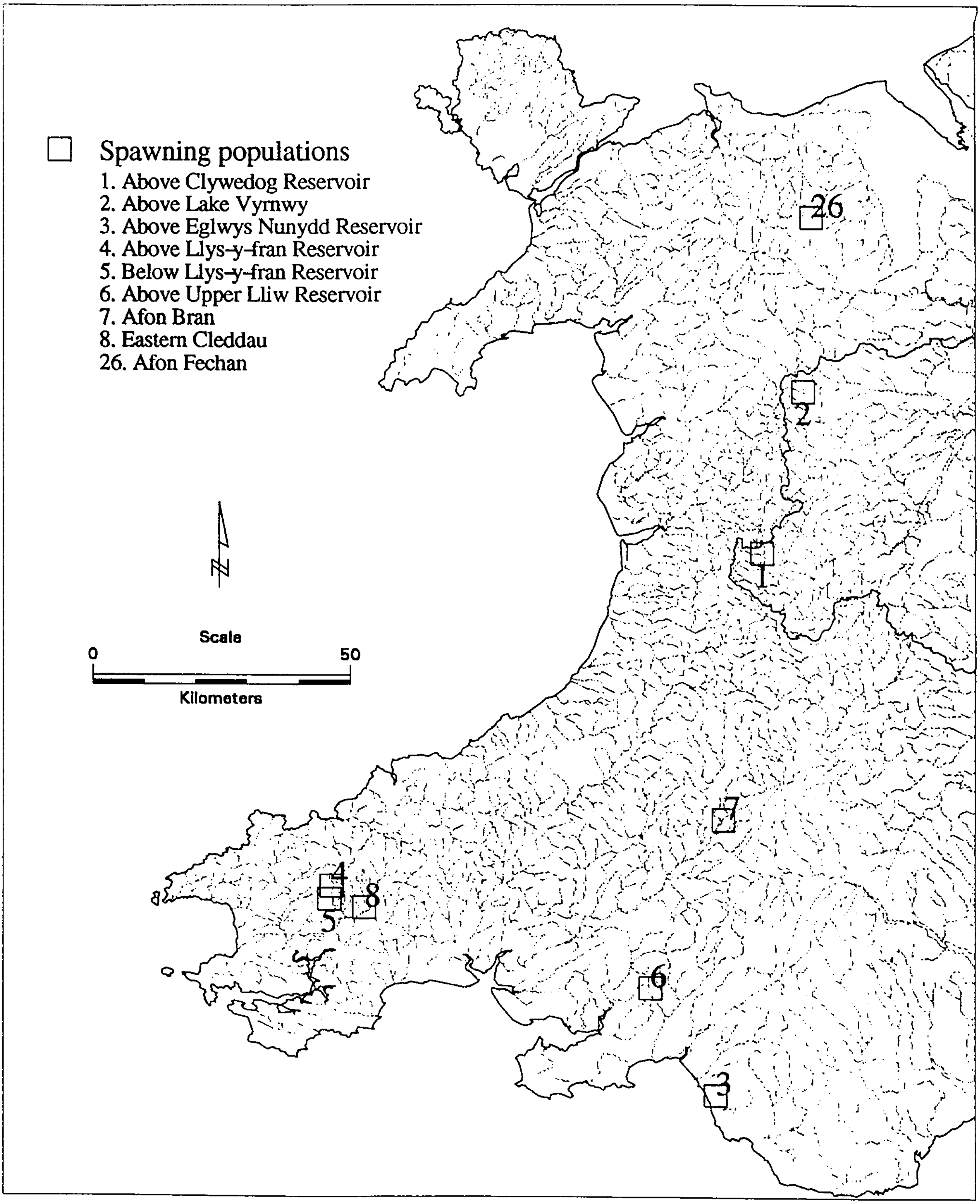
□ Spawning populations

1. Above Clywedog Reservoir
2. Above Lake Vyrnwy
3. Above Eglwys Nunydd Reservoir
4. Above Llys-y-fran Reservoir
5. Below Llys-y-fran Reservoir
6. Above Upper Lliw Reservoir
7. Afon Bran
8. Eastern Cleddau
9. River Haddeo, below Wimbleball Lake
10. Compton Vallence Stream
11. River Chew
12. Hollow Brook
13. Above Clatworthy Reservoir
14. Above Sutton Bingham Reservoir
15. River Biss
16. Above Hawkridge reservoir
17. Bourne Rivulet
18. River Test, Stockbridge
19. River Len
20. Above Tittesworth Reservoir
21. River Mimram
22. River Frome
23. River Piddle
24. Ampney Brook
25. River Wye
26. Afon Fechan
27. Above Siblyback Reservoir
28. Above Stithians Reservoir
29. River Gwash, above Rutland Reservoir
30. River Eyebrook, above Rutland Reservoir
31. River Derwent
32. Black Beck, above Esthwaite Water

△ Self-sustaining populations

1. River Wye, Haddon Hall
2. Carl Beck




Spawning populations
1. Above Clywedog Reservoir
2. Above Lake Vyrnwy
3. Above Eglwys Nunydd Reservoir
4. Above Llys-y-fran Reservoir
5. Below Llys-y-fran Reservoir
6. Above Upper Lliw Reservoir
7. Afon Bran
8. Eastern Cleddau
26. Afon Fechan
Scale
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Kilometers
26
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□ Spawning populations

9. River Haddeo, below Wimbleball Lake
10. Compton Vallence Stream
11. River Chew
12. Hollow Brook
13. Above Clatworthy Reservoir
14. Above Sutton Bingham Reservoir
15. River Biss
16. Above Hawkridge reservoir
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24. Ampney Brook
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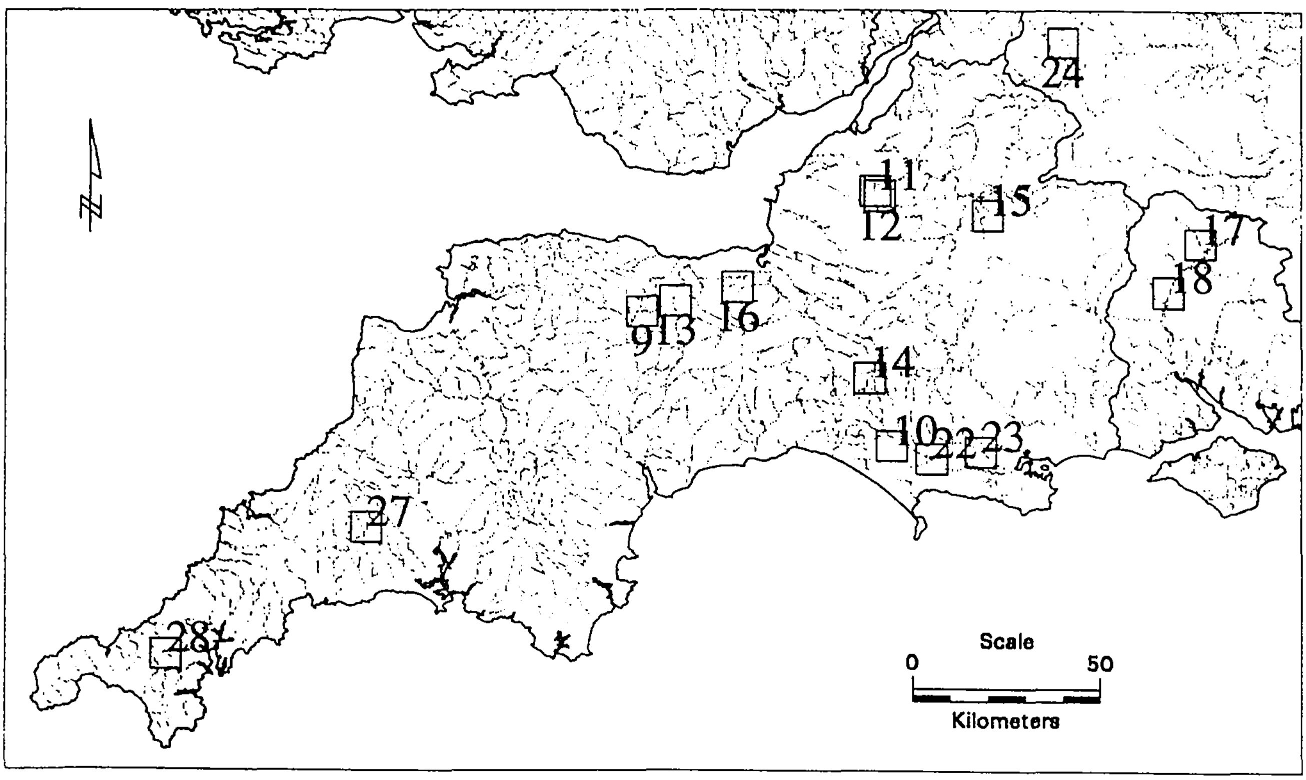
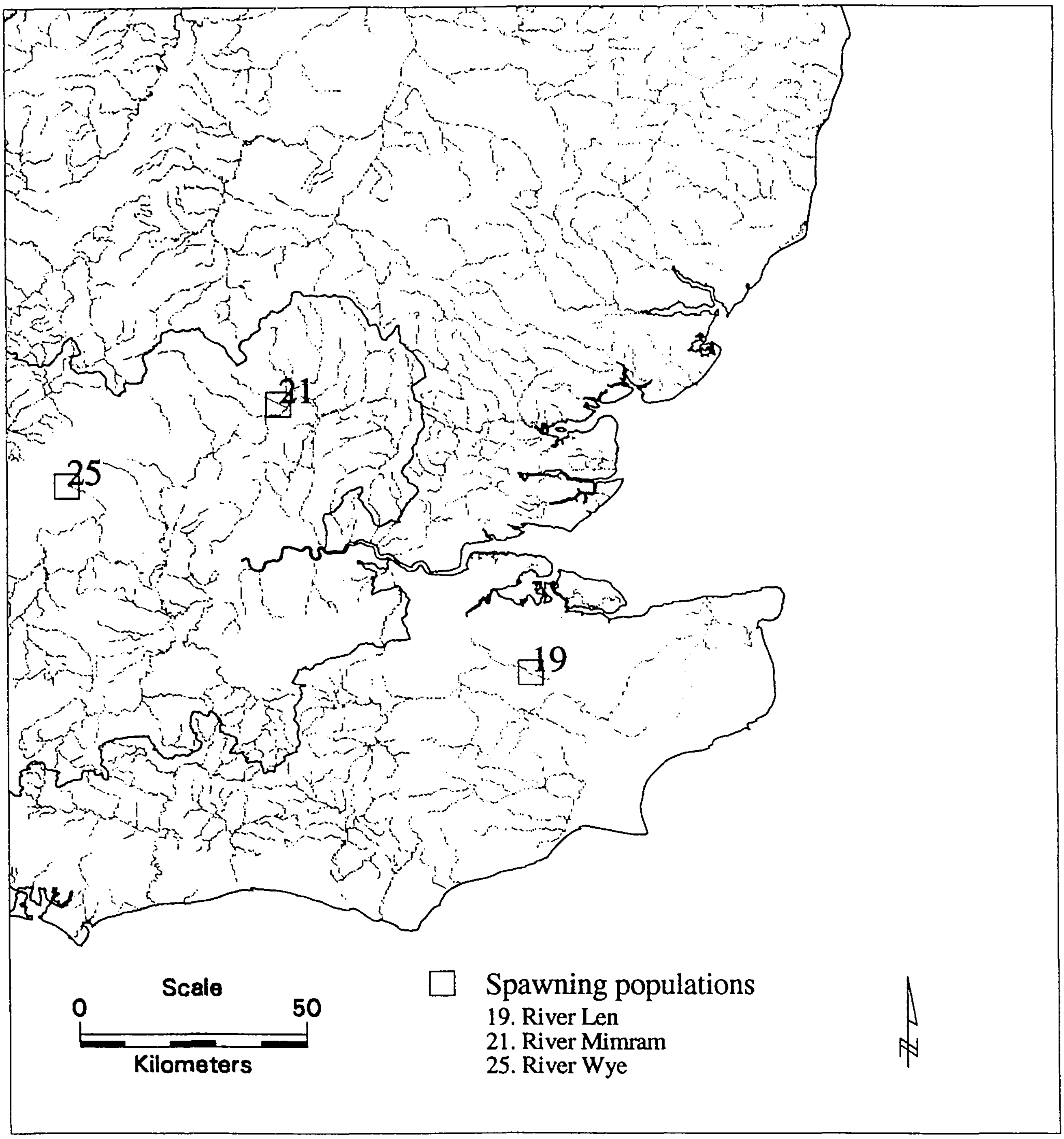
28. Above Stithians Reservoir




21
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Spawning populations
19. River Len
21. River Mimram
25. River Wye
N

□ Spawning populations
20. Above Tittesworth Reservoir
29. River Gwash, above Rutland Reservoir
30. River Eyebrook, above Rutland Reservoir
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1. River Wye, Haddon Hall
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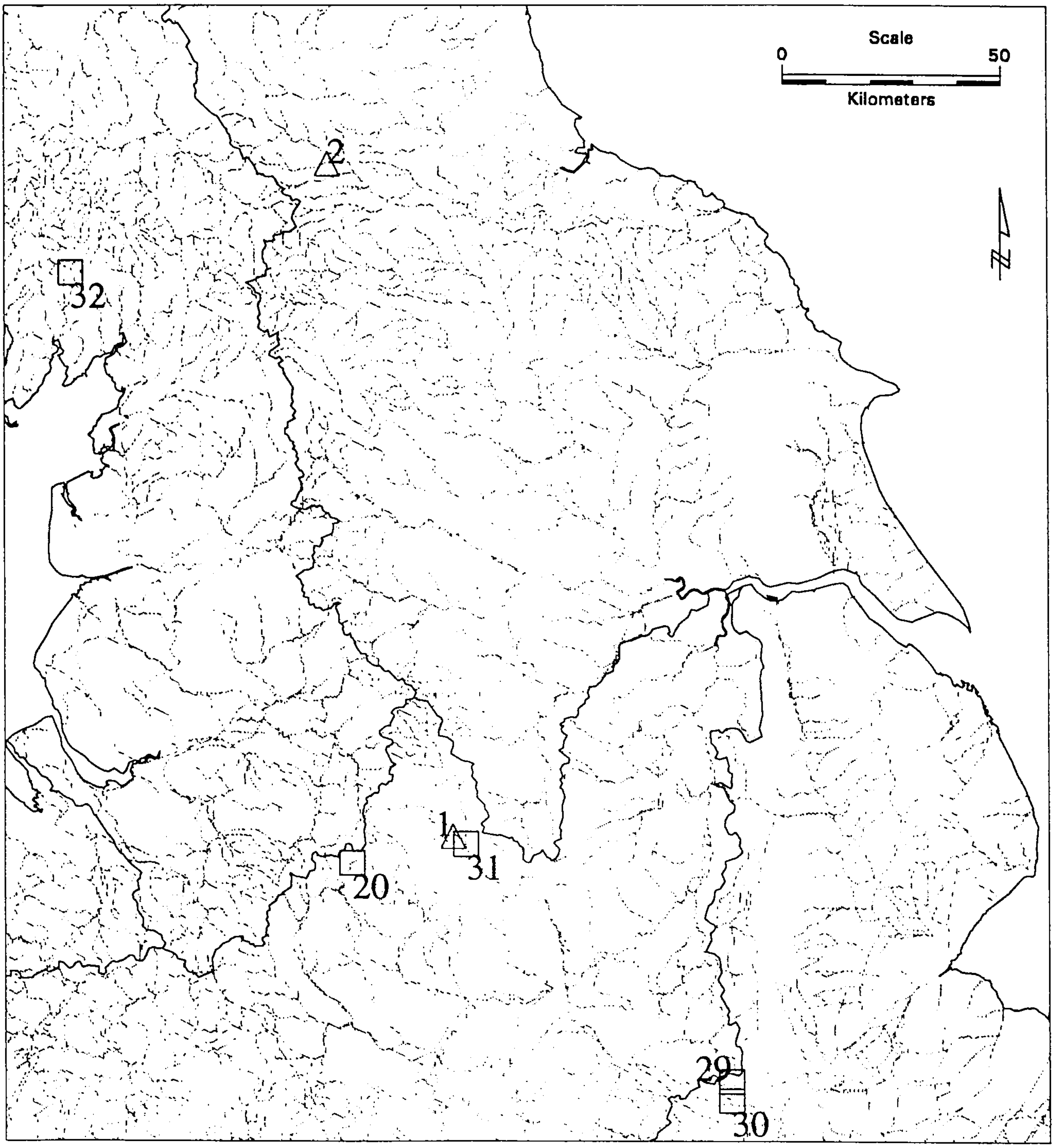

6. RISKS FROM STOCKING RAINBOW TROUT

6.1 Introduction

The risks of stocking rainbow trout fall into a number of categories; competition for space and food, predation on other species, and the transmission of disease.

6.1.1 Competition

Competition can be for space or food but generally these are linked in that salmonid fish compete for territories which have a good food supply which is easy to access. There is evidence in the literature for competition between rainbows and other salmonids (see Section 2.5.2) at both the juvenile and adult stage. Some data exists from Northumbria and Yorkshire Agency on the Carl Beck population. It is postulated that rainbows are having an adverse effect on brown trout. From observed densities of 0+, 1+ and 2+ fish of both species it is suggested that 1+ brown trout have a reduced density due to interaction with the high density of 1+ rainbows. Mean lengths are also given and indicate that brown trout are smaller than rainbows of the same age and also smaller than the equivalent aged brown trout in an adjacent tributary. It has also been shown that in both of the self-sustaining populations, there have been instances of strong year-classes of rainbows being associated with weak year-classes of brown trout and vice versa.

6.1.2 Predation

The only hard evidence of predation on other fish species by rainbows is a study on the stomach contents of rainbow trout in the Devon area of South West Region when juvenile salmonids were found in some stomachs. It has also been reported that large rainbows in Esthwaite Water (North West Region) have been seen eating fry. Although the piscivory has never been quantified, the fact that these fish do eat juvenile salmonids should be enough to give cause for serious thought about the wisdom of introductions into rivers and in particular chalk streams where salmon are already in decline and where it is important to maximise numbers of smolts as far as is possible.

6.1.3 Disease

The only serious disease of rainbow trout which is known to affect brown trout (also coregonids and pike) is VHS. There seems to be no evidence of disease transmission from rainbows to other species. The fact that the Agency require health checks on farmed fish introduced into rivers should be sufficient to prevent the introduction of diseases.

6.1.4 Impacts

Within the Agency regions, there is little evidence of impacts from stocked or accidentally introduced rainbow trout. This includes rivers where spawning has been attempted, others where there have been historical introductions over many years and those where large numbers of escapees are common.

Considering the number of waters that contain rainbow trout in this country, there is almost no evidence that they are damaging native fish stocks significantly. It is probable that the Agency rolling stock programme has not been in place sufficiently long to show an effect nor are these surveys designed for this purpose. The experiences in other countries appears to be different, with more evidence of impacts of rainbow trout in North America, New Zealand and on the continent. It is possible that the policy of put and take river fisheries has existed longer than in the UK and there has thus been more time for impacts to become apparent.

In the Alpine Rhine Valley, rainbow trout have started to reproduce naturally in the last 10-20 years as a result of stocking practices (Peter pers. comm.). Presently, stocking has ceased but the species has established natural populations and they have begun to invade all the tributaries of the Rhine. In the alpine region, brown trout and rainbow trout are failing to co-exist. In many rivers and streams, over 90% of the trout populations are rainbows and the brown trout is now considered to be an endangered species. The situation is not confined to running waters, Lake Constance now has a resident rainbow trout population also. Peter is due to finish a report on this in May and has three papers in preparation.

In North America, there are said to be strains of rainbow trout breeding in every month of the year. A species as plastic as this is almost certainly going to impact on native fish in some habitats.

7. ESCAPES OF RAINBOW TROUT

7.1 Introduction

Rainbow trout can be stocked intentionally, both legally, when Section 30 consent has been given by the Agency, and illegally, when permission has not been sought. They can also appear unintentionally, usually by escaping from a fish farm in the locality (the majority of cases from the Regions). Fish escaping from reservoir cages may run up feeder streams or migrate into rivers downstream. This is also true of escapes from reservoirs and lakes where fish have been placed legally (North East Region). Escapes from marine or estuarine cages may also run up rivers where no fish farms exist (Welsh Region). Being potentially anadromous, there is also the possibility of fish which originated from fish farms migrating to sea and returning as steelheads to rivers. In this way the species may colonise new habitats. There are some self-sustaining populations and there is also the possibility that progeny will colonise adjacent rivers or streams either during the juvenile stage or as steelheads after a period at sea. Juveniles of the Carl Beck population, migrate downstream from the spawning site into the main River Lune (a tributary of the Tees) and thereafter, information on these fish is sparse. Some rainbows have been seen around the barrage on the lower Tees and some steelheads have been caught off the river mouth. Fish return at a large size to Carl Beck presumably as steelheads. One rainbow has been found in the adjacent River Balder which may be a stray fish from the R. Lune or may represent a population in the R. Balder itself.

7.2 Results

Each Agency Area was asked to comment on the magnitude of escapes of rainbow trout and to assess their origins and whether it was perceived to be a problem. Response varied from no information, no escapes, no fish farms in the area to large scale escapes on a regular basis mainly of small fish but occasionally of adults. Information is collated in Appendix 3.

7.3 Conclusions

Generally, escapes resulted in some initial annoyance to anglers when many of these fish, which are usually small, were caught. In the longer term, most escapes disappeared within a year and no impacts were apparent. There have been isolated instances where escapees have paired up or have bred successfully (see Section 5.2) but even in theses cases, no impacts were apparent on native salmonids.

8. EXPERIMENTAL DESIGNS

8.1 General comments on experimental studies

There have been very few worthwhile experimental studies on the interactions between introduced rainbow trout and native species. Despite the large numbers of introductions of non-native salmonids which have taken place Fausch (1988) states that "very few investigations have provided good evidence either supporting or refuting competition between species". Most studies that have been carried out suffer from the following deficiencies - lack of manipulation, high levels of variation between streams, lack of controls and/or replication and/or unnaturalness of conditions. It is, of course, necessary to avoid "pseudoreplication" (by repetition of treatments in different streams) and "demonic intrusion" (by monitoring over a sufficient period of years to avoid being confounded by the 'one-off' event) in setting up experiments.

Further to the above, the design of experiments should be such as to establish whether addition or removal of the competing species has a greater, lesser or different effect to adding or removing similar numbers of intraspecific competitors. Designs should, ideally, follow the principles set out by Underwood (1986).

In any experiment designed to test the impact of an introduced species, the choice of response variables to be measured is critical. Variations in factors such as population density, reproduction/recruitment and survival of impacted fish would have to be measured over several years (generations), in a given stream, to obtain meaningful results. Population densities could only be determined by repeated fishing and removal or by mark-recapture studies (possibly in small areas of shallow stream by observation), preferably in situations where the fish were confined within the study reaches. Recruitment and survival could be determined by repeated estimates at appropriate times of the year.

Alternatively mortality, natality (emigration/immigration) etc. of different age classes of the "target" species in sympatry and allopatry can be compared between streams but the conditions are rarely, if ever, the same and the assessment of population changes can be very difficult.

Two types of experiment can be used to establish competition between species. Firstly, it is possible to examine *natural* situations in which the species of concern occur in sympatry and in allopatry (Sale 1979, Pianka 1981). Such experiments are limited by the assumption that the habitats studied differ only in the presence or absence of the study species - a most unlikely event. In the case of *controlled* experiments (Hearn 1987) the limitations often lie in the inability to examine all life stages or in the unnaturalness of the experimental environment.

Thermal conditions could affect the nature and levels of interactions (Stein et al. 1972; Rimmer et al. 1984; Cunjak and Power 1986). Care should be taken to avoid low population densities caused by environmental extremes or by high levels of predation since, under these conditions, density dependent factors may not operate or may be greatly reduced in intensity.

8.2 Nature of possible impacts

Stocked rainbow trout have potential interactions with salmon, brown/sea trout, charr, grayling and other coarse fish. The interactions may take place at any life stage or between different life stages of the species involved. Presumably it is possible that introduced fish (rainbows) might even benefit other species, in the short term, by eating competitors, 'absorbing' parasites preferentially, 'feeding' pike etc. In the long term however even such interactions are likely to affect natural populations in an adverse fashion.

There are a number of areas of interaction which are difficult to detect or investigate by traditional methods. For example, interaction with other species (brown trout) may take place chiefly at night or in deep or turbid water. Such interactions could be studied by means of radio/acoustic tagging. This would be of value in relation to feeding and food competition aspects. Since competition for food in salmonids is generally subordinate to territorial interactions the latter is probably the more important area for study.

The major unknowns are firstly, to what extent are rainbow trout predators and if so is there an impact at the population level? Secondly, the number of self-sustaining populations are very few and the mechanisms controlling this are not understood. It was decided, in consultation with the Project Officer and comments from the members of the Project Board to concentrate on these two issues. A list of possible experiments and their objectives are given in Section 8.3 below and experiments 8.3.1 and 8.3.5 are planned in detail and costings are given.

8.3 Experiments to assess potential impact of rainbow trout on native salmonids

8.3.1 Predatory interactions

Objective

To determine to what degree stocked rainbow trout are piscivorous and whether, by being so, they adversely affect other species at the population level.

8.3.2 Territorial conflicts

Objective

To establish whether introductions of young rainbow trout adversely affect natural populations of young brown trout/salmon.

8.3.3 Spawning interactions

Objective

To establish the conditions under which rainbow trout spawn naturally in Britain. To study the disturbance by introduced rainbow trout on spawning activity of other species.

8.3.4 Circumstances for generation of self-sustaining populations

Objective

To determine whether recruitment of young only takes place following recent introduction of mature fish.

8.3.5 Investigation of the biology of self-sustaining populations

Objective

To investigate the biology of existing self-sustaining populations with a view to determining behaviour patterns and risk of proliferation of such populations.

8.3.6 Conclusions

Discussions with the Project Officer and Board members have highlighted two of the experiments, 8.3.1 predatory interactions and 8.3.5 Investigation of the biology of self-sustaining populations as high priority for Phase 2 and these are expanded below.

8.3.1 Predatory interactions

Overall objective

To determine to what degree stocked rainbow trout are piscivorous and whether, by being so, they adversely affect other species, particularly salmonids, at the population level.

Background

Although examples of predation by rainbow trout in the literature are few, they have been reported as eating various juvenile stages of Sockeye, Chum and Pacific salmon in North America. From stomach content analysis, hard data exists in the Agency South Western Region of rainbow trout eating juvenile salmonids and rainbows have been seen eating fry (of unknown species) in Esthwaite Water in North West Region.

Introduction

The impact of piscivorous rainbow trout on the various life stages of natural salmonids (and other freshwater fishes) needs to be assessed. The component life stages of potential prey organisms should be studied. It is likely that the juvenile stages (eggs, alevins, fry, parr and smolts for example) are the most vulnerable and that experimentation will need to cover most periods of the year in order to assess fully the impact on these stages. Quantification of the amounts eaten will depend on good estimates of population density of the piscivore (rainbow trout) and of the prey (particularly salmon) as well as the use of digestion rate models to establish probable rates of food consumption at different temperatures (times of the year).

Approach

The experiment should be divided into two sections, the first to determine whether rainbow trout predate on any of the juvenile salmonid stages and secondly to quantify this predation should it exist.

Site selection

Given that the River Test in Hampshire receives high numbers of large rainbow trout (over 30% of all introductions in the Southern Region are into rivers), then this river should be chosen for the study. In recent years, the amount of stocking of trout in rivers has increased considerably. For example, in the R. Test in Hampshire, stocking has increased from 1000, 20 years ago, to the present total of 20,000 in just one stretch of the river. Within this stretch, one reach stocked 1400 fish and the average weight of fish caught was 3.2 lb. Reaches should be chosen where good estimates of the piscivore population could be obtained.

Alternatively, if the necessary permissions cannot be obtained, sites where quantitative estimates of fish populations have been made should be chosen and where large rainbows are stocked in high numbers.

Methods

Assess methodologies for obtaining stomach contents

The use of emetics and stomach pumps (several types) will be assessed both from the literature and from practical trials. These trials will be conducted to assess the effectiveness of the techniques in determining food items consumed. Dissections will be made to ensure that the whole of the stomach contents have been regurgitated. The survival rate from the emetic and stomach pump methods will also be assessed. The ideal method will be one in which the total stomach contents can be examined without harm to the fish. If this proves impractical then sacrificial sampling will be undertaken and an equivalent number of rainbows will be introduced as replacements for the fishery. It is possible that newly introduced rainbow trout might be less piscivorous than well established stocks. In view of this, every effort should be made to use a stomach pumping technique to remove the gut contents for examination and to return the fish to the river afterwards. This approach will also reduce the need to restock after sampling.

Determine which life stages are predated upon

This will require careful planning as it requires samples to be taken at stages in the life history of the prey species which may only last a short time. Sampling will be concentrated into critical periods when piscivory may be expected to occur. These include the time the alevins leave the redds, the early part of the year when parr are small and the time of the smolt run. It may also be necessary to sample during the winter, when invertebrate food is at a minimum to determine whether piscivory becomes more prevalent.

Identify the amount of previous stocking carried out in the study river

This will depend on the co-operation of both the Agency personnel in supplying names and addresses of riparian owners/angling clubs and the latter in supplying stocking information.

Identify the sizes of stocked fish, their origins and the stocking densities used

This will depend not only on the co-operation of the owners/angling clubs but also on their historical records of sizes of fish stocked. It may be possible to obtain sizes from the supplier of the fish.

Evaluate the effects of stocked rainbow trout on natural fish populations

The information gathered on piscivory and stocking will be assessed and the effects of stocked rainbow trout on wild salmonids will be evaluated using digestion rate models to determine the annual biomass of fish eaten. This will then be compared with the known production of salmon as assessed from the adult and smolt counting programme on the river. Care will be taken to ensure that any effects identified are discussed in the light of other regulatory processes in rivers. For example, it is not sufficient to conclude that a certain percentage of wild fish are eaten and therefore limiting stocking would increase the density of wild fish. Many other processes, both density dependent and environmental, will be influencing the wild stocks and the relative importance of these will vary between rivers and populations.

Produce recommendations on future trout stocking policies so as to minimise or avoid deleterious effects on wild fish populations

The conclusions of the study will form the basis for the recommendations on future trout stocking policy. For example, it is probable that careful timing of stocking could reduce piscivory by protecting some vulnerable stages of the prey species.

Work plan

Year 1

Determine the best method of obtaining stomach contents by experimentation. Determine the survival rate for each method. **(5 man days)**

On each field occasion, sample approximately 100 rainbow trout from several (minimum 3) sites, and collect the stomach contents by the appropriate technique as determined by experimentation.

Sampling monthly between November and January to provide information about egg and parr predation, during March, April and May for emerging alevin, fry and smolt predation and during the summer (July, August and September) for parr predation. **(minimum 36 man days, could be double depending on the ease of catching the rainbows)**

Collected and preserve stomach contents on site.

Sort and examine stomach contents in the laboratory and quantify the fish element. (**10 man days**)

Collate and analyse results **(2 man days)**

Produce Interim Report **(5 man days)**

Year 2

If a positive result is found from year 1, repeat field sampling programme **(36-72 man days)**. Determine density of predators (rainbow trout) at each site by multiple-shock electric fishing at each impacted stage of the life cycle of the prey. (educated guess, 3 times of the year at four sites **48 man days**)

Repeat lab procedures **(10 man days)**

Estimate total annual consumption of prey by rainbow trout. **(2 man days)**

Using data on egg and alevin numbers estimated from adult population statistics and parr/smolt numbers from Agency surveys, determine the impact of piscivory on salmon populations. **(3 man days)**

Produce Interim Report **(7 man days)**

Year 3

Repeat Year 2 sampling and lab work **(94-130 man days)**

Analyse data **(5 days)**

Evaluate the effects of stocked rainbow trout on natural salmon populations. **(2 days)**

Produce recommendations on future rainbow trout stocking policies so as to minimise or avoid deleterious effects on wild fish populations **(2 days)**

Produce Final Report **(10 days)**

Cost for 3 year project £150,000 maximum

This should cover the costs of replacing rainbow trout should it prove necessary to remove fish unless they are all of a particularly large size.

8.3.5 Investigation of the biology of self-sustaining populations

Objective

To investigate the biology of existing self-sustaining populations with a view to determining behaviour patterns and risk of proliferation of such populations

Background

Even though the conditions in many streams and rivers seem to be conducive to the reproduction and recruitment of rainbow trout, there are only two known self-sustaining populations in the Agency Regions. By studying these populations, it may be possible to determine the likelihood of such populations spreading.

Introduction

Work By Dr D.T.Crisp is already in progress on Carl Beck funded by Northumbrian Water. Two marked reaches in Carl beck are triple fished each year in mid to late August. This gives information on the population densities of all salmonids, particularly 0-group brown and rainbow trout. A wider area is non-quantitatively electrofished to sample older juvenile rainbows (lengths measured and scales taken). Although some pre-smolt rainbows have been observed in the Spring, there is no evidence of any synchronised mass movement of rainbows out of Carl Beck as smolts. Results of surveys suggest a gradual departure around the first winter.

Adults are sampled in the spring at spawning time. Length, sex and gonad condition (ripening, ripe, spent) are determined and scales are taken.

The question that remains is where do these juveniles go? The fact that they return as large fish at a young age suggests that they have been to sea and are returning steelheads although they may just have been in the lower reaches of the river where growth is faster due to increased temperatures and better food availability. Although there are known to be wild fish breeding, the possibility remains that recently stocked fish (even though they are all females), escaping from Grassholme Reservoir may be helping to sustain this population. More work is required on adult numbers and fecundity (this is already being considered by Dr Crisp).

Site selection

Sites on the Carl Beck and the Derbyshire Wye should be considered but as work is already in progress on Carl Beck this is the most cost effective site for the Agency in that it can build on a programme that is already in progress.

Methodology

Year 1

Increase the electrofishing programme to sample as high a proportion of the juvenile rainbows as possible. This should be carried out in September. Adipose fin clip these fish. Take scales from a sample. The following day, electrofish to obtain a subsample to determine the percentage of fin-clipped fish in the population and, by mark recapture, the approximate total population.

Take scales from a sample of juvenile brown trout.

Operate the trap in the Tees barrage at the appropriate times of year to monitor possible emigration of smolts and immigration of adults. The timing of operation should be determined after consultation with staff already monitoring the fish pass.

Sample adults in Carl Beck, looking for adipose clipped fish. Examine scales for age and growth determination to elucidate the origins of the fish (most farmed fish will have scarred scales although some wild fish may also have scarred scales resulting from damage during spates).

Analyse scales for Sr^{90} levels which indicates whether the fish have been to sea.

Sample adults and measure length sex and gonad condition. Measure ripe egg size and relate to female length. Determine fecundity.

Install temperature logger for assessment of egg development and to monitor the temperature profile of a stream known to be suitable for a self-sustaining stock of rainbow trout.

Analysis

Determine growth rates from scales and predict the likelihood that the fish had been to the sea. Compare with scales analysed for Strontium.

Determine ratio of adults with and without adipose fin.

Determine the fecundity - length relationship and compare the size of ripe eggs with those of brown trout.

Predict hatching time of rainbow and brown trout eggs from the temperature profile.

Compare growth rates in the juvenile phase with those of brown trout from the same area to determine whether their growth rates are faster than brown trout.

Prepare a report to R&D standards.

Repeat for a further 4 years (there will be no need to adipose clip juveniles in Years 3 and 4).

Prepare final R&D Report.

Potential problems

There was no spawning of rainbows in Carl Beck in the Spring of 1996. Whether this was due to general low river flows or the new barrage is unknown. However, successful spawning was observed in 1997.

Costs

Depend on the scale of the research. Studies in the beck itself should be relatively cheap (**<£5000** to include equipment). Costs for operating the barrage trap depend on whether Agency staff are involved and whether the trap is being operated for other purposes. The costs for scale analysis for Strontium are not known but it is expected to be about £50 per scale.

9. CONCLUSIONS

Although information on the impacts of rainbow trout on the natural salmonids of the UK is sparse, several facts are known.

1) Agency policy on the introduction of rainbow trout is variable and should be standardised as far as possible between Regions.

2) A review of Section 30 consents showed that a high percentage of introductions are into lakes and most introductions into waters are large fish ie of a takable size.

3) Although rainbow trout are known to breed in a number of rivers there are only two documented instances of self-sustaining stocks.

4) In other countries, self-sustaining populations have impacted on natural salmonids to such an extent that in the Alpine Rhine valley, brown trout are now considered to be an endangered species.

5) There are no known instances of impacts of stocked rainbow trout on charr populations. However, because in North America introduced rainbows are known to have had adverse effects on brook trout (a species of charr) any planned introductions of rainbow trout to lakes containing Arctic charr should be considered carefully, particularly where the charr use rivers for spawning and rearing of juveniles.

6) It is also known that rainbow trout are piscivorous although the significance of their predatory activities on natural salmonid populations is not known. However, in situations where populations are in decline, such as salmon populations in southern chalk streams, any level of piscivory may be undesirable.

7) There is strong socio-economic pressure to produce put and take fisheries and it is impractical to ban introductions altogether from all running water systems. Rainbow trout are generally easier to catch by anglers and this often governs their introduction rather than using brown trout. The problem then is whether to introduce rainbow trout or brown trout. Opinion differs over which species to choose, rainbows, ostensibly an alien species or brown trout which may cause a problem of genetic degradation of wild stocks.

8) It is known that brown trout are also piscivorous and indeed may be more so than rainbow trout.

9) There seems to be no evidence of disease transmission from rainbows to other species.

10) In order to avoid the possibilities of increasing numbers of self-sustaining populations and the consequent impacts on endemic salmonids it would be wise to use all female or sterile stock for introductions either to rivers or where fish have potential access to running waters.

11) Care should be taken to avoid stocking into rivers where recolonisation of another fish species is being encouraged eg salmon in the R. Thames.

12) It would be unwise to allow introductions of rainbow trout into this country from stocks which appear to be more successful in creating self-sustaining populations eg Alpine Rhine stock or wild bred fish from North America.

13) In situations where genetic contamination of wild brown trout stocks is likely to occur and where pressure for stocking is irresistible, then rainbow trout are a more acceptable option.

14) Some thought should be given to the timing of introduction of stocked fish. At present a large proportion of fish are introduced before the trout season at a time when natural salmonid alevins are appearing from redds. By delaying stocking until this has occurred it may be possible to minimise the piscivory on this stage of the life cycle.

15) In conclusion, this report concludes that introductions are a fact of life and it would be almost impossible to ban. Steps should therefore be taken to limit the impact on natural salmonids. This can be done, in general, by introducing all female or sterile stock. In situations where pure wild stocks of brown trout exist, for example, they should be protected by banning introductions, but if this cannot be achieved then rainbows should be introduced rather than genetically polluting brown trout. In rivers where stocks are at a sensitive level, eg salmon in southern chalk streams, thought should be given to the piscivorous nature of both rainbow and brown trout and decisions made on whether any losses to piscivory can be afforded.

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Appendix 1 Letter sent to all Area FRCN Managers

River Laboratory
East Stoke
WAREHAM Dorset
BH20 6BB

7 September 1995

Dear

The IFE is reviewing the Impact of Stocked Rainbow Trout on Resident Salmonid Populations, for the NRA, under R&D Project D02(95)04. The contract requires us:

(1) to review existing NRA data on the impact of rainbow trout on resident salmonid populations, and
(2) to review existing NRA policy including existing practices (i.e. what is stocked where and why) and historical introductions.

Please will you supply for your area the following information.

1. **Any data regarding the impact of rainbow trout on resident salmonid populations.**
2. **Details of your local NRA policy on stocking.**
3. **Details of stocking practices within your area covering issues such as numbers, size, location, origin and reason for stocking.**
4. **Any data on historical introductions of rainbow trout.**
5. **Maps indicating where self sustaining rainbow trout populations are known to exist within your area.**

I would also greatly appreciate available information on known or perceived risks of stocking and any instances of escapes of rainbow trout into the wild.

There is a tight schedule for the collation of this information, and to comply with this the information is required by the end of September 1995 at the latest.

Please contact me by phone if you would like to discuss this request.

Best Wishes

Anton Ibbotson (Dr)

Appendix 2 Letter sent to all Regional FRCN Managers

River Laboratory
East Stoke
WAREHAM Dorset
BH20 6BB

Telephone (01929) 462314
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Facsimile 01929 462180
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Dr J. Hilton BSc PhD CChem MRSC
Assistant Director

25 September 1995

Dear

NRA R&D PROJECT D02(95)4 Impact of Stocked Rainbow Trout on Resident Salmonid Populations. Phase 1.

Recently, you will have received a copy of a letter sent to your Area FRCN Managers requesting information for the above project. At a recent meeting with Tony Owen, the Topic Leader, he suggested that the Regional FRCN Managers were better placed to supply information on **policy**, including existing practices.

I would be grateful for any information from your region on stocking policy for rainbow trout, either as an official policy document or from papers and minutes of RFAC meetings if these are available.

Yours faithfully

Dr J.S.Welton

Appendix 3 Data from Agency Regions on escapes of rainbow trout

Anglian

Central

Escapes occur into one localised spot on the R. Nar which is a SSSI with a natural brown trout population. There is no known adverse impact.

North East

Escapees have been documented at various locations. In the R. Coquet, rainbows are believed to have escaped from lakes. Similarly, escapees found in the R.Wear are believed to have come from two reservoirs and from a trout farm during a flood. Escapes from a hatchery occurred into the R. Wansbeck and R. Fon and from a fish farm into the W. Beck (River Hull trib).

North West

Central

Escapes have been recorded from a fish farm on the R Wenning on the Lune system.

North

There have been complaints from anglers of catches of rainbows inferred as escapees. There is a belief that there are periodic escapes from fish farms on Esthwaite Water, the R. Marron, R Eumont and Ewes Water on the Border Esk.

Midlands

Upper Trent Area

Possible escapes on the River Dove after complaints from brown trout fishermen who were catching rainbows.

Lower Trent

No information

Upper Severn

No major problems. Small numbers regularly turn up in the R. Severn and in tributaries which are associated with trout farms.

Southern

Sussex

Escapes from a fish farm on R. Adur have been reported.

Kent

No data

Hampshire

Fish farms on both the R. Test and R. Itchen have escapes which Agency staff feel are inevitable. Agency staff have been called on to occasionally remove numbers of rainbows particularly from the R. Itchen.

South West

North Wessex

There are only a small number of farms and very few known episodes of escapes.

Devon

No data

South Wessex

Very large numbers of rainbow trout escape from fish farms in the Fordingbridge area of the R. Avon. Major escapes occur every spring. In the upper Avon there have been significant escapes in the past but this has not occurred for some years. Escapes on the R. Piddle are common and there were massive escapes in the 70s and 80s into the R. Frome.

Thames

North East

No data

South East

A number of rivers have small numbers of escapees. A large escape of 50,000 occurred recently on the upper Wey South. Many were removed by the Agency. Any impact has yet to be assessed.

West area

No data

Welsh

South Western

This area has produced a report entitled 'A report on the studies into the effects on native salmonid stocks of two large scale escapes of rainbow trout in the Cleddau catchment (Whightman 1988). There were two large escapes of rainbow trout parr (180000) and adults (unknown number) in the

Cleddau catchment in August 1986 and surveys in June and July 1987 were undertaken to determine whether there had been a deleterious effect on the native salmonid population. The surveys caught no adult rainbows and only small numbers of parr at two sites. Although late cut redds were observed in Jan-Feb 1987, large numbers of salmon fry were subsequently found in these areas. Rainbow trout fry were found in small numbers at only one site indicating very limited spawning success. Although no stomach content analyses were performed, very high densities of native salmonids were found where adult rainbow trout were observed to have congregated in 1986. The conclusion of the report was that there was no cause to suspect that significant predation had occurred or that there had been any adverse impact of the escapes on native fish. The vast majority of these escapees had left the freshwater system within the year.

The fact that rainbow parr were only found at sites with very low densities of native salmonids could indicate that the escapees could not compete and were displaced into sub-optimal habitats.

Northern

No data